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AMERICAN SOCIETY OF CIVIL ENGINEERS

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Journal of the
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WATER QUALITY PROBLEMS IN THE COLUMBIA RIVER BASIN[a]

Herbert C. Clare,[1] M. ASCE

ABSTRACT

The paper discusses problems of maintenance of high water quality throughout the Columbia River Basin. As the economy matures, the preventive pollution control program of the area becomes increasingly important. The public in the Pacific Northwest is anxious that as much waste as possible be kept out of waters of the Columbia Basin.

INTRODUCTION

The Columbia River is the greatest natural resource in the Pacific Northwest. Its drainage basin covers an area of approximately 220,000 square miles in the United States (about 7.2% of the total land area of the U. S.) plus some 40,000 square miles in British Columbia, Canada. Contributing to the Columbia River system are waters of the States of Montana, Wyoming, Utah, Nevada, Idaho, Oregon and Washington and the Canadian Province of British Columbia. Besides the portion of the Columbia River Basin which is in British Columbia and that area draining directly into the main stem of the river, the Basin consists of the following major tributaries and their subbasins: (1) The Kootenai; (2) Clark Fork-Pend Oreille; (3) Spokane; (4) Yakima; (5) Snake and (6) Willamette.

Ground waters, although in general of less importance than the surface waters in the Basin, have a high actual and potential value in a number of localities.

The Columbia River is the greatest actual and potential source of water power in North America. In an average year it discharges a total of approximately 180 million acre feet of water to the sea. Its flow is well maintained

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a. Presented at the June, 1958, ASCE Convention in Portland, Ore.

1. Officer in Charge, Water Supply and Water Pollution Control, Pacific Northwest, Public Health Service, Portland, Ore.

during the summer season since its headwaters are fed by perpetual snow fields and glaciers and since a great deal of storage is provided in the Basin. During the late fall and winter when the temperature at the upper elevations are normally below freezing the stream flow decreases reaching a minimum in December.

The Columbia River Basin has undergone relatively recent development. The first settlement was established in the Basin in 1811 (by the Astor party). The greatest early influx of people occurred, however, near the middle of the nineteenth century, at about the time of the discovery of gold in Idaho and other parts of the West.

The tremendous natural resources of the Pacific Northwest have created a vigorous economy which is now typical of the area and assures its continued rapid development. For example, the Columbia Basin produces an annual lumber yield of over 10 billion board feet—approximately 35% of the nation's total.

During and since the second world war trends in the Pacific Northwest have been toward industrial and recreational development and expansion of irrigation. The most important natural resources of the area are its water, agricultural lands, forests, mineral deposits, fish and game, and scenic beauty. The economy depends heavily upon the use of its water resources for hydroelectric power, transportation, commercial and sports fishing and recreation. Use of water is also very important for domestic and industrial as well as agricultural purposes including the irrigation of some 4.5 million acres of land or 17% of the total irrigated acreage in the United States. In the foreseeable future irrigated acreage in the Basin is expected to reach 8.5 million acres. This means that irrigation is a critical water use and will become more critical as development of the Basin continues. Another use of water within the Basin is for carrying away treated community wastes which are a necessary consequence of modern civilization.

The greatest factor influencing the industrial and economic growth in the Pacific Northwest has been the development of hydroelectric power. The extractive industries—agriculture, lumbering, and mining, as well as related processing and manufacturing enterprises—have greatly expanded because of low cost electric power and water made available for irrigation by the construction of multipurpose storage reservoirs.

The pulp and paper industry is extremely important in the Basin. For years pulp mills have operated on the Lower Columbia River. As recently as five years ago a pulp and paper mill was constructed at Lewiston, Idaho, on the Clearwater River near its confluence with the Snake River. Very recently a mill was placed in operation on the Clark Fork just below Missoula, Montana. A mill is now under construction at Attalia, Washington, on the McNary pool of the Columbia River near the Mouth of the Snake. Another is planned for the Kootenai River Sub-basin in Montana. Reconnaissance surveys in the Basin have revealed the presence of adequate raw materials for one or more additional pulp mill installations on every major tributary of the Columbia River, as well as on the main stem.

Commercial and sports fisheries are of great importance. While commercial fishing is limited to the lower stretch of the Columbia River, sports fishing is intense throughout the Basin. The Columbia River and many of its tributaries are important spawning streams for extensive fisheries not only on the river and its tributaries, but also along the Pacific Coast. Several varieties of salmon, as well as trout and steelhead, spawn in the Basin.

Recreation is rapidly becoming a factor of primary importance throughout the Pacific Northwest. It is now actually considered as a major industry with a value of approximately $1 billion annually. At least 35 million recreation visits are made to this area each year. The Basin includes many of the remaining wilderness areas of the nation. A combination of ideal year-round climate, excellent scenery, and exceptional recreation opportunities make the Basin popular with summer vacationists, winter sport enthusiasts, hunters, and fishermen. Tourists are making increased use of parks and recreational facilities located along waterways and highways. To meet the ever increasing demand of tourists and vacationists these park facilities are of necessity being rapidly increased in size and number.

Water Quality Problems

Problems of water quality in the Basin's water courses are caused by discharge of sewage and industrial wastes, return flow irrigation water, and improper watershed practices. Approximately 20 per cent of the organic pollutional load is contributed by municipalities and 80 per cent by industries.(1) Other problems are bacterial pollution, siltation, and toxic and inorganic wastes. Sylvester in a study sponsored by the U. S. Fish and Wildlife Service (1957)(2) found that water quality has experienced a significant change during the past 45 years as a result of the construction of dams in the Basin. These dams have made water available for such consumptive uses as agriculture and domestic and industrial uses. Sylvester found that spent waters from these consumptive uses produced these water quality changes more than did the dams themselves. Irrigation return-flow waters are more highly mineralized and have different physical properties than applied waters. Their return to a stream or to the ground water will produce marked changes in water quality, especially if the quality of return-flow is appreciable, in relation to the volume of the receiving waters. Irrigation water of satisfactory quality has a low enough salt content that it extracts minerals from the irrigated land and does not deposit them, thus carrying these salts to the receiving waters in solution.

An important factor in water quality in the Columbia Basin is that of temperature. Fig. 2* shows information on temperature and anadromous fish migration. Among the harmful effects of increased water temperatures are higher disease rates, lower oxygen tension, and direct physiological effects.

The most severe bacterial and organic pollution occurs in the Willamette River Sub-basin; in the highly developed irrigated valleys of the Snake River Sub-basin; and in the Yakima River Sub-basin. The greatest degredations in water quality in the Basin caused by discharge of inorganic wastes occur in those streams receiving tailings from ore concentration mills, and from dredges, smelters and ore precipitation plants. Other important factors contributing to the pollution of the waters of the Basin are silt and debris from agricultural, range, and cut and burned over forest lands.

In any discussion of water quality problems in the Columbia Basin it must be kept in mind that the States within the Basin, with the help and cooperation of the Public Health Service, are carrying out effective overall programs of water pollution control.

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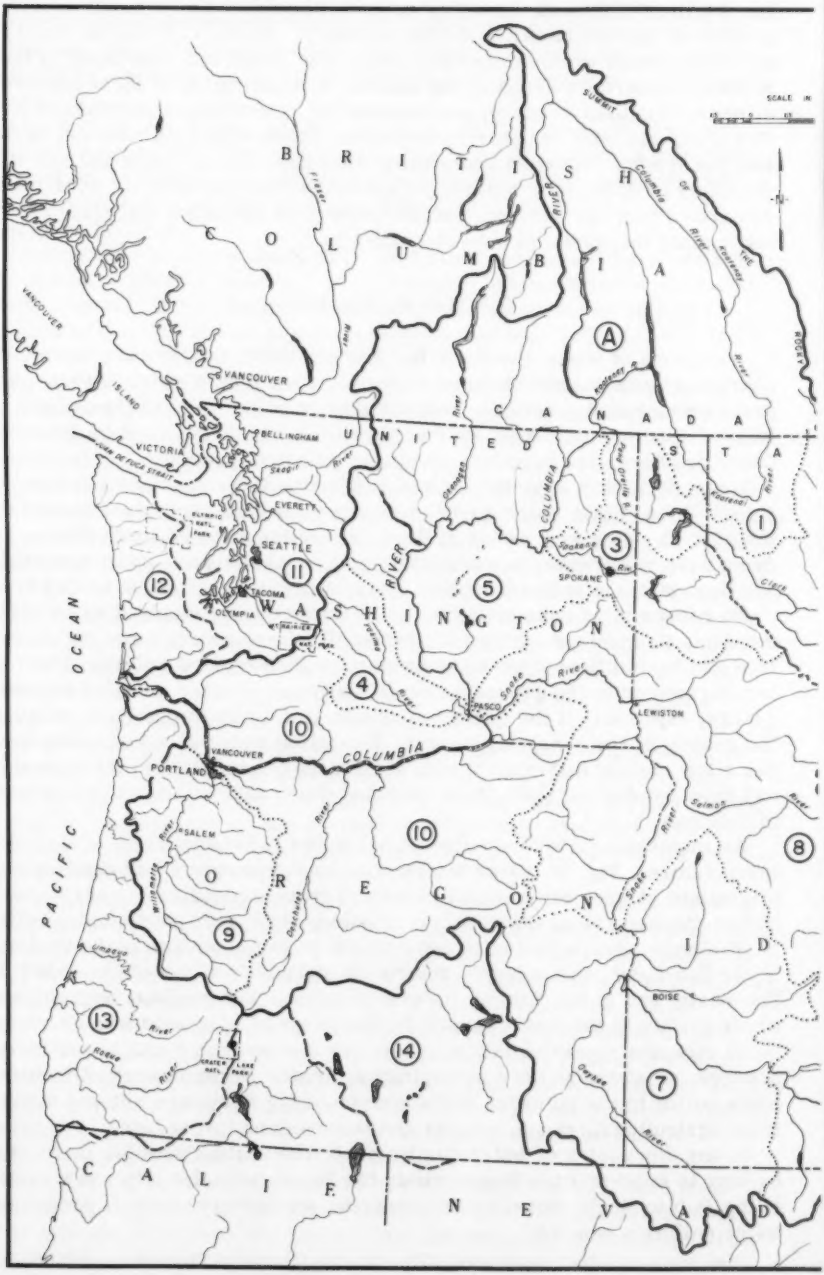
*Prepared by R. F. Foster, Manager Aquatic Biology, Biology Operation, Hanford Laboratories, from U. S. Army Corps of Engineers reports.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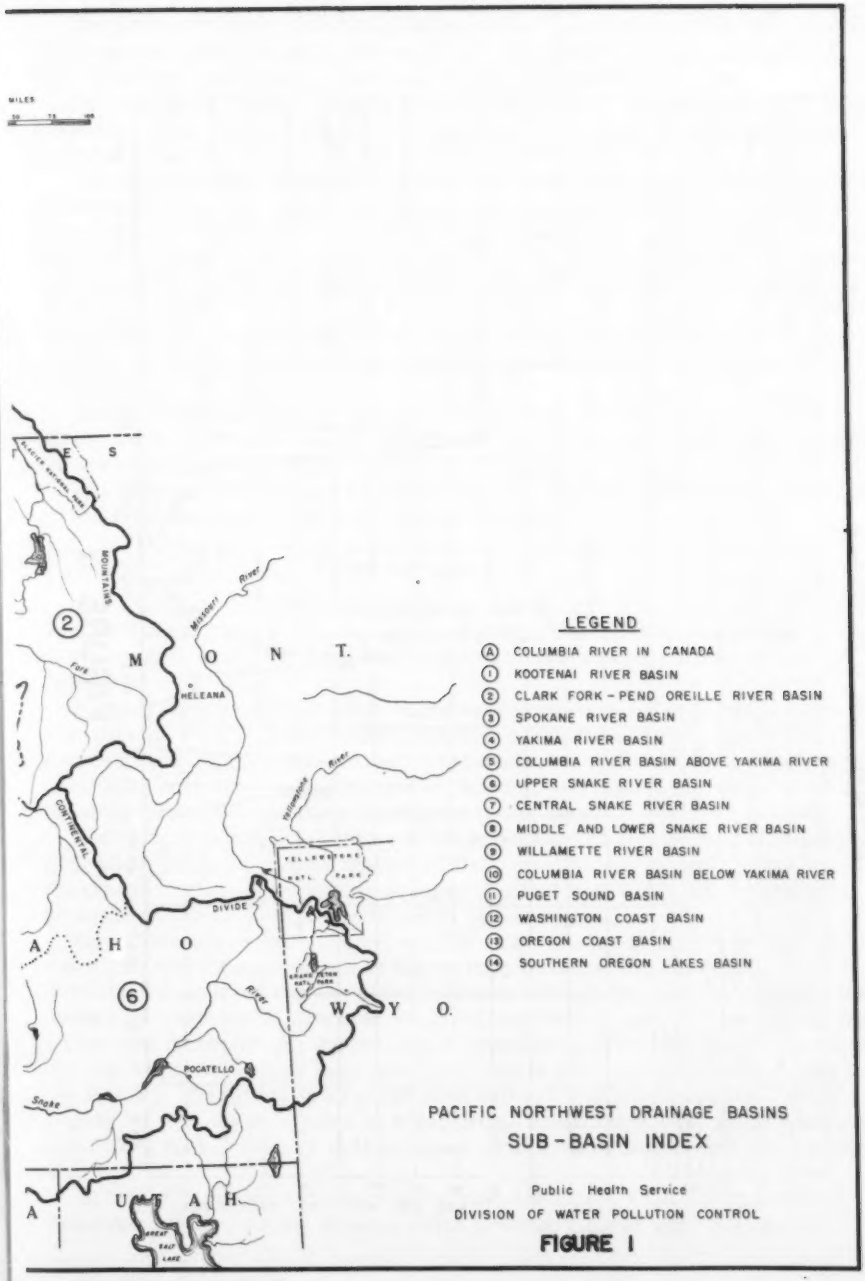

PACIFIC NORTHWEST DRAINAGE BASINS
SUB-BASIN INDEX

Public Health Service
DIVISION OF WATER POLLUTION CONTROL

FIGURE 1

COLUMBIA RIVER TEMPERATURES AND SALMON RUNS AT BONNEVILLE DAM

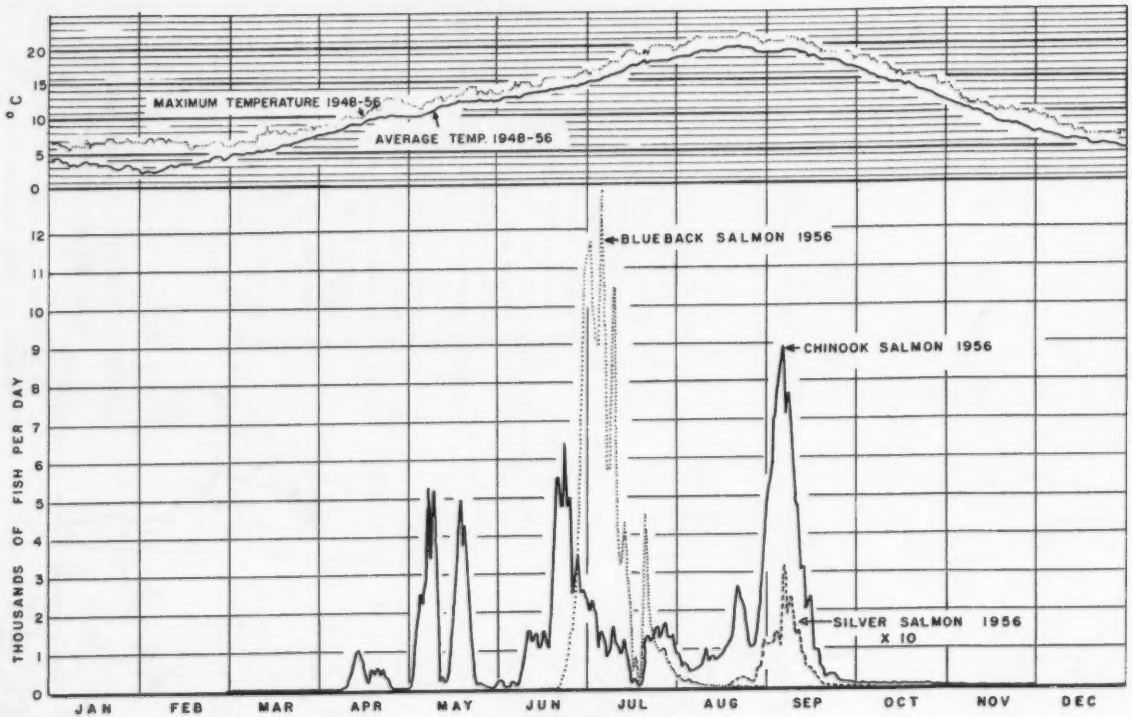

FIGURE 2

Kootenai River Sub-Basin

The Kootenai* River Sub-basin is located in southeastern British Columbia, northwestern Montana and northern Idaho. Its natural resources consist of fertile valley lands, huge timber resources and mineral deposits.

The Sub-basin's water resources have not been extensively utilized. Uses consist of domestic and industrial supplies from surface sources, irrigation, power production, recreation and fish and wildlife.(1)

The Myrtle Creek Watershed of this Sub-basin which is the source of the Bonners Ferry water supply provides an example of improper watershed management in that adequate control was not exercised over location and construction of logging roads built into and in the watershed for use in harvesting and salvaging mature and diseased timber. Although this watershed serves as an example of what the U. S. Forest Service can do to correct errors in watershed management and restore proper management conditions, the quality of water from this area has been degraded to a degree that additional water treatment is necessary.

The principal problem in this Sub-basin is one of flood control. Each spring there is a crisis caused by flooding conditions along the river and often extensive damage occurs as a result of flooding.

The Montana State Board of Health plans to conduct a water quality survey on the Kootenai River during the summer of 1958.

Clark Fork-Pend Oreille River Sub-Basin

The Clark Fork-Pend Oreille** River Sub-basin includes most of Montana west of the continential divide, a part of the panhandle of Idaho, a small area in the northeastern corner of Washington and two separate areas in British Columbia.

Natural resources of the Sub-basin have tremendous developmental potentialities. Its mineral deposits, forests, agricultural lands, and water resources have not yet been utilized extensively. In addition to the development of irrigation and hydroelectric power, mining, and lumbering, recreation is valuable from an economical standpoint in the area.

Water uses in the Sub-basin are for domestic and industrial water supply, irrigation, recreation, propagation of fish, wildlife, hydroelectric power, and the transportation and booming of logs. A great portion of the Sub-basin's potential hydroelectric power is yet to be developed.

One of the areas in this Sub-basin in which wastes affect the quality of water is near the headwaters in the vicinity of Butte and Anaconda, Montana.(3) In this area the river receives sewage from municipalities, and industrial wastes which include the discharge from a precipitation plant; from a smelter; from ore milling and other operations. The precipitation plant reclaims copper and other minerals dissolved in water pumped from mines in the locality. Recovery is accomplished through replacement of dissolved copper by iron whose source is scrap iron. Resulting wastes contain an average of 250 ppm of iron as well as small quantities of copper and other minerals.

Recently dams were constructed across the Clark Fork River below Anaconda forming impoundments which presently cover approximately 2

*Kootenay in Canada.
**Prend d'Oreille in Canada.

square miles. These impoundments serve as lagoons which control wastes from the Butte-Anaconda area. This results in satisfactory water quality below the impoundment. Downstream municipalities are now proceeding with installation of sewage treatment works.

In the vicinity of Missoula the Clark Fork River receives partly treated and untreated sewage, and wastes from beet sugar refineries, rendering and meat packing plants, a Kraft pulp mill, and other industrial plants.

In 1957 the Montana State Board of Health with the assistance of the Montana State Fish and Game Department and the Public Health Service made a study of the Clark Fork River below Missoula to establish basic conditions prior to introduction of wastes from the Kraft pulp mill recently constructed there. The study is being repeated this summer by the Montana State Board of Health, with the assistance of the State Game Department, to determine changes in water quality brought about by wastes from the Kraft mill which recently started operation.

Some 200 miles below Missoula, the Clark Fork crosses the Idaho-Montana line and within a short distance enters Pend Oreille Lake. This large lake has always had water of high quality. In it are found whitefish, blueblack salmon and the famous Kamloops trout. The outlet of Pend Oreille Lake, the Pend Oreille River, is at Sandpoint, Idaho. From this point to Albeni Falls Dam, the river receives sewage from the City of Sandpoint, Idaho, where a sewage treatment plant is now under construction and seven miles above the crossing of the Idaho-Washington boundary it receives treated sewage from the City of Priest River, Idaho. The communities of Dover and Priest River take their drinking water supplies from the Pend Oreille River.

In the vicinity of Metaline Falls, Washington, the Pend Oreille River receives tailings from lead and zinc ore concentration mills.(4) In Canada the river receives wastes from gold, lead, and zinc mining operations. When mines in the vicinity of Metaline Falls and in Canada are operating at capacity, approximately one million tons of tailings per year are discharged into the lower Pend Oreille River.

Spokane River Sub-Basin

The Spokane River Sub-basin includes an area of some 6,600 square miles in northern Idaho and eastern Washington. The principal tributaries are the Coeur d'Alene and St. Joe Rivers, both of which have their headwaters in the Bitterroot Mountains on the Idaho-Montana boundary, and discharge into Coeur d'Alene Lake. The outlet of this lake is the Spokane River which a few miles below the outlet crosses the Idaho-Washington line and flows some 100 miles in a westerly direction before joining the Columbia River in Franklin D. Roosevelt Lake above Coulee Dam.

Agricultural lands, forests, minerals, and water are all of importance in the Sub-basin's economy. These resources have been fairly well developed and have led to intensive industrial development centered about Spokane, Washington, and in the Coeur d'Alene mining district.

Water has had an important part in the Sub-basin's economic development. Hydroelectric power, recreation, and irrigation are water uses that are important to this economy. Other uses are for domestic and industrial water supply, fish and wildlife. Floods are a problem on the Coeur d'Alene River.

Major pollution problems of the Spokane River Sub-basin are caused by discharge of raw and partially treated domestic sewage, tailings from ore

concentration mills and related metal refining plants and waste from a sulfite pulp and paper mill and a variety of other industrial plants. The three principal areas where significant quantities of pollutional waste are discharged into the river system are: The South Fork of the Coeur d'Alene in Idaho and the main stem of the Spokane River at Millwood and Spokane, Washington.

In Idaho, municipalities along the South Fork and its tributaries discharge raw sewage into this branch of the Coeur d'Alene River. Also discharged in the vicinity of these communities are tailings from some 25 ore concentration mills. These tailings contain large quantities of inorganic matter including small quantities of lead, zinc, manganese, iron and copper. It is estimated that approximately one-half million tons of tailings are discharged into the river annually when mining operations are normal in the Coeur d'Alene mining district.

Some 20 to 25 years ago, extensive water quality surveys were made along the Coeur d'Alene River system by the Idaho Department of Health, U. S. Public Health Service, U. S. Bureau of Fisheries, and the U. S. Bureau of Mines, and several of the mining companies in the district. Since 1934 the Idaho Department of Public Health has made monthly tests of samples of Coeur d'Alene Lake water submitted by the water utility operators at Coeur d'Alene. Results indicated a range of lead concentration in that water supply of from less than 0.005 to 0.086 ppm.

The reduction of lead concentration in the Coeur d'Alene water supply intake may be due in part to operation of the Cataldo dredge which started in 1932. This dredge operates in the channel of the Coeur d'Alene River in the vicinity of Cataldo where the gradient of the river decreases to a point where flows and turbulence permit settling of the mill tailings carried to that point from mining and milling operations along the South Fork. Reductions may also be due to introduction of the more efficient flotation process of ore concentration which replaced the jig table method used previously.

The community of Millwood, Washington, is located on the Spokane River above Spokane. A sulfite pulp and paper mill located at this point discharges organic wastes estimated to have a population equivalent of approximately 175,000.

Sewage from the City of Spokane enters the Spokane River below the city and it is estimated to have a population equivalent of approximately 200,000. In addition, wastes from some industries discharging through separate outlets directly to the river are estimated to have a population equivalent of 50,000 to 55,000. At the present time the City of Spokane is placing a primary sewage treatment plant in operation. This will result in material improvement in water quality below Spokane.

Yakima River Sub-Basin

The Yakima River sub-basin is entirely within the State of Washington and includes an area of approximately 6,000 square miles in the south central part of the state. The Yakima River flows for a distance of approximately 200 miles from its source on the eastern slopes of the Cascade Range to the Columbia River. The economy of the sub-basin is based almost entirely upon irrigated agriculture. It is one of the oldest and most productive irrigated areas of the Pacific Northwest. About one-fourth of the total acreage in farms within the basin is irrigated, and more than one million acre-feet of water storage has been provided to supplement natural sources for irrigating

these lands. Present diversions from the river for irrigation result in extremely low flows in some stretches of the main stem below Yakima during the late summer months.

Important uses of the sub-basin's water resources, other than irrigation, are for domestic and industrial water supplies, fish and wildlife, hydroelectric power, and recreation.

Pollution of the streams has damaged the water resources of the Yakima River Sub-basin.(6) Besides the municipalities within the basin such as Yakima, Ellensburg, and Toppenish, which discharge partially treated sewage to the system there are numerous food processing industries discharging industrial wastes which contribute pollutional loads. Damages to the sub-basin's water resources have been recognized by the Washington State authorities since the beginning of the century. Although considerable progress has been made toward abatement, pollution still causes some damage and interferes with other water uses.

Studies made by the Washington State Department of Health between 1935 and 1950 indicated that high rates of enteric diseases have repeatedly occurred in the Yakima Valley. Reductions in these rates have been made since sewage treatment plants were constructed.

Irrigation return waters exert a pollutional effect on downstream waters by changing the chemical quality and by introducing bacterial contamination and silt. These and other damages conclusively indicated the need for carrying to completion a comprehensive pollution control program supported by all the people living in the basin. Such a comprehensive program(6) was adopted by the State of Washington and the Public Health Service under the Federal Water Pollution Control Act.

Consideration has been given to supplementing the flow of the Yakima River for the purpose of reducing pollution and for the benefit of fisheries. Agencies which consider augmenting the flow are quick to emphasize that they want no part in a plan which would substitute dilution water for adequate treatment of wastes. However, the benefits of increasing the flow of a stream which receives treated wastes are readily apparent to public health and pollution control officials who are anxious to reduce the degree of pollution in these waters. Such benefits are also apparent to irrigators who use the water on their lands, and to fish and wildlife people who would like to have a higher quality and an adequate quality of water for propagation of fish.

This matter has been given considerable attention by organizations in the Pacific Northwest that would like to see increased capacity built into the Bumping Lake Reservoir on the Yakima Project for the purpose of supplementing the flow of the Yakima River during late summer and fall for the benefit of pollution control and fish and wildlife. A precedent would be set by constructing such additional storage in this project, since there would be no direct reimbursement for the additional cost of this construction.

Snake River Sub-Basin

The Snake River is the largest tributary of the Columbia River system. It drains an area slightly in excess of 110,000 square miles, or about one-half of the total area of the Columbia River Basin within the United States. It covers parts of the States of Wyoming, Utah, Nevada, Idaho, Oregon, and Washington.

About two-thirds of the total area of land under irrigation in the Columbia Basin lies in the Snake River sub-basin. Ultimately this fraction will be about one-half of the expected total of 8.75 million acres in the Columbia drainage area.

The principal uses of the sub-basin's water resources are for domestic and industrial water supply, irrigation, recreation, hydroelectric power, and propagation of fish and wildlife. The middle and lower portions of the sub-basin are of major importance to the anadromous fisheries in the Pacific Northwest. The fish that spawn in this sub-basin are an important part of the commercial fishery of the Lower Columbia River, as well as of the ocean trawl and extensive sport fisheries. The sub-basin has undergone an extensive development for navigation and power production and this development is continuing. Two power dams are presently under construction in the Halls Canyon section of the Snake River system between Idaho and Oregon. Another which will benefit navigation is under construction at Ice Harbor just above the confluence with the Columbia River near Pasco.

Pollution exists in the highly populated irrigated valleys of the Snake River system.(1) This pollution results from soil erosion, discharge of raw and partially treated sewage by a number of municipalities in the area, from seasonal discharge of wastes from beet sugar refineries, potato-starch plants, and other food processing industries. It is estimated that the organic wastes discharged to the river frequently exceed population equivalents of 4 million.

Many municipalities at the present time are constructing or planning to construct sewage treatment facilities. Industries are also making progress in the control of organic wastes from food processing plants. For example, sugar refineries in the sub-basin no longer discharge Steffens wastes. These are being processed elsewhere for by-product recovery.

There are three areas in the sub-basin which are potential interstate pollution problems. One of these areas is along the Snake River between Oregon and Idaho from the mouth of the Boise River to a point below Weiser, Idaho, just above Halls Canyon. This section of the Snake River is below the relatively highly populated Snake and Boise River Valleys in southern Idaho.

At Lewiston, Idaho--Clarkston, Washington the Snake River receives untreated sewage from the City of Lewiston, primary treatment plant effluent from the City of Clarkston, and wastes from a Kraft pulp and paper mill and small industries. The City of Lewiston is presently constructing a primary sewage treatment plant. Asotin, Washington, a few miles upstream from Clarkston, is also building a treatment plant.

The third area in which there may be interstate pollution is on the Palouse River system where the river and its tributaries cross the Idaho-Washington line between Potlach, Idaho, and Palouse, Washington; between Moscow, Idaho, and Pullman, Washington, and in the vicinity of Geneses, Idaho. In this instance there is a problem of the high turbidity which occurs at times of heavy runoff. Erosion is extensive in the Palouse country wheatlands.

The Atomic Energy Commission has an installation in the sub-basin in the vicinity of Arco, Idaho. These AEC operations are located at the lower end of the Lost River system where the Big and Little Lost Rivers, Birch, Medicine Lodge and Camas Creeks disappear into the lava flows underlying the desert of the Snake River Plain. None of these streams has a surface outlet to the Snake River. Therefore, radioactive and other wastes from these operations which ultimately enter the Snake River system must do so through

buried channels underlying the areas and presumably having their outlet in the "Thousand Springs" emerging from the north wall of the Snake River Canyon between Twin Falls and Bliss, Idaho.

The AEC has a program of monitoring wastes discharged to the ground and ground water in the vicinity of its Arco operations. This discharge of radioactive wastes is and will continue to be a problem requiring close surveillance.

Willamette River Sub-Basin

The Wilamette River Sub-basin has a total drainage area of some 11,000 square miles, all within the State of Oregon. It is the most heavily populated Sub-basin of the Columbia River drainage area. Its 1950 population was 873,000.

Forests cover approximately 60 per cent of the sub-basin area and provide a continuous annual yield of almost two billion board feet of timber. There is extensive farming in the sub-basin. Sports and recreation opportunities make the tourist business the third largest industry of the sub-basin.

Economic development has resulted largely because of readily available water resources. Water uses are for domestic and industrial water supplies, irrigation, propagation of fish, transportation, recreation, and production of hydroelectric power. All of these uses are undergoing additional development and are becoming increasingly important.

Major pollution of the Willamette and its tributaries is caused by the discharge of sewage effluents from approximately one-half million people and wastes from 7 pulp mills, and a variety of other industrial plants.(7) Pollution has interfered with full development of fisheries and has detrimentally affected recreational areas. In its 1957 progress report on water pollution control in Oregon,(8) the Oregon State Sanitary Authority indicated that all cities on the main stem of the Willamette River now have sewage treatment works. All major sources of industrial wastes in the sub-basin have some form of treatment or waste disposal facilities. This Progress Report states that some sections of the Willamette River and some of its tributaries were significantly polluted during the 1957 summer season. In some areas recreational use was interfered with.

The Oregon State Sanitary Authority further reported that on occasions during the summer of 1957 the dissolved oxygen content of the water in Portland Harbor was reduced to less than the minimum amount required for fish. The Santiam River below the City of Lebanon was also polluted to the point where it could not support fish life. In some sections slime (Sphaerotilus) growths developed to a very significant extent below industrial wastes discharges. The Oregon State Sanitary Authority found that pollution in the Willamette River during 1957 was worse than it had been during the previous three years. This condition was due to some extent to lower than usual flows during the critical low flow period of July, August and September.

Some 80 sewage treatment plants in the sub-basin serve a sewered population of 543,000 people, plus industrial waste with an estimated population equivalent of 544,000 people. The combined efficiency in terms of oxygen demand reductions of all the industrial waste treatment and disposal facilities was estimated at 57%. For the five sulfite pulp mills in the basin this efficiency was estimated at 62%.

The Columbia River in Canada

The Columbia River system drains some 40,000 square miles in Canada. Principal water uses in addition to domestic and industrial water supplies include hydroelectric power, irrigation, recreation, and navigation.

The largest hydroelectric power installation in the area is located on the lower Kootenay River. Power from this installation supplies the mining and smelting development at Trail, B. C., as well as the domestic and industrial power needs of many communities in the basin.

The area includes some 140,000 acres of agriculture lands dependent upon irrigation. Ultimate irrigated acreage is estimated as 538,000 acres. Rivers and lakes in the area contribute in great measure to recreational uses. The Canadians, as well as the people in the Northwestern United States, recognize the importance of the Columbia River System to the prosperity and ultimate development of British Columbia and the Pacific Northwest.

The Canada Department of Mines and Technical Surveys, Mines Branch, Industrial Minerals Division, in its Water Survey Report No. 4,[9] indicates that waters of good quality exist in general throughout the Canadian portion of the Columbia River Basin. This study revealed no waters which were unsuitable for irrigation. A few small tributaries were found to be polluted with mine waste but it was concluded that the amount of these wastes had apparently little effect on the main stem.

Bacterial pollution was not considered to be a problem because of the large volume of water and relatively low population densities.

The Water Survey Report indicated that industrial expansion within the basin should be possible with little effect on water quality provided reasonable precautions were taken to protect the waters of tributaries and to restrict the amount of wastes entering the main rivers.

The Columbia River above Yakima River

The drainage area of the main stem of the Columbia River above the Yakima River (excluding the Spokane River drainage and that portion that lies within Canada) lies entirely within eastern Washington. The upper Columbia's abundant water resources will be the principal factor in further development of the area.

The availability of hydroelectric power from numerous dams, and an abundant supply of high quality water were reasons for locating the important Atomic Energy Commission operation at Hanford in this sub-basin.

Besides extensive use of water for hydroelectric power development, for irrigation and for the AEC operations, other uses for waters of this area are for domestic and industrial water supply, livestock watering, recreation, and fish and wildlife.

Irrigation in the Columbia Basin, which is being carried on extensively at the present time, and which will increase as projects under construction are completed, introduces the problem of changes in water quality due to irrigation return flows into the Columbia River. Domestic and industrial wastes being discharged into the river are also increasing because of population influx and expansion of industrial processing resulting from the Columbia Basin Irrigation Development.

The AEC plant at Hanford requires tremendous quantities of clean water in its operation. Water resource developments and uses on the Columbia River above the Atomic Energy plant which would change the chemical and

physical properties of this water could seriously handicap the processing of radioactive materials.

The AEC has a thorough program of monitoring wastes discharged to the ground and Columbia River in the vicinity of its Hanford operations. Present information indicates that the concentration of radioactive materials in wastes discharged by that plant is below established tolerance standards. This is true in spite of the fact that operations at Hanford have been expanded and have resulted in an increase of radioactivity being released to the Columbia River.(10) AEC recognizes its responsibilities in connection with radioactive wastes discharge and close surveillance which is required.

Neutron radiation causes impurities in process waters used at Hanford to become radioactive. Upstream operations or developments which would increase the turbidity of the river from which the Hanford Works water supply is taken would result in increase of radioactivity in effluent water. Such operations or developments would include construction of upstream dams, irrigation return flow, mining and industrial operations in the Upper Columbia River and its tributaries, or floods.

A new uranium ore refinery at Ford, Washington started operations within the past year. However, no increase in uranium concentration in the Columbia has been observed from this plant. Special analyses for uranium at 13 locations on the River below Richland in April (1956) showed a range of 0.7 to 1.5 ug/cc averaging 1.1 ug/cc (7.3 x 10 - 10 uc/cc).(11)

The Hanford Laboratory of the AEC makes weekly measurements of principal mineral constituents in the Columbia River at Hanford. The annual averages which have been reported are summarized in Table I.

The radioactivity of waste entering the Columbia River from the Hanford Works has been under constant surveillance since the start of plant operations. Since 1948 radioactivity of the effluent reaching the river has shown a continued increase. As would be expected, this increase is reflected in the quality of the river water (Water Quality Study on the Columbia River, Public Health Service, Sanitary Engineering Center, 1954).

Excessive ionizing radiation has long been recognized as a health hazard. Observations and studies of the damaging effects of X rays and radium have provided a basis for establishing the limits for various types of radiation. However, problems facing State agencies in handling treatment and disposal of radioactive wastes are relatively new.(12) With the advent of nuclear reactors, many radioisotopes have been identified, and the need for more specific knowledge regarding their effects on man and his environment has become apparent. It is for these reasons that radioactivity similar to that which is now present in the Columbia River below Hanford is of vital importance to the people of the Columbia River Basin, and the control of this radioactivity within safe limits is a recognized responsibility of the Atomic Energy Commission, its operating contractor, public health officials and many others.

The Lower Columbia River Below Yakima River

The Columbia River drainage below the mouth of the Yakima River, exclusive of the Snake and Willamette sub-basins, comprises an area of some 80,000 square miles in Washington and approximately 26,000 square miles in Oregon.(1) Land elevations are more variable than in other sub-basins of the Columbia Drainage System. They vary from sea level at the coast to 14,400 feet, the elevation of Mt. Rainier which is on the Columbia Basin boundary.

TABLE I

MINERAL CONSTITUENTS IN THE COLUMBIA RIVER AT HANFORD (10)

	Annual Average -- Parts per Million					
	1952	1953	1954	1955	1956	1957 (10 months)
Solids	100	95	87	82	86	89
Hardness		68	72	74	77	69
Calcium	21	20	22	24	24	21
Magnesium	5.2	4.5	3.8	3.7	4.0	3.9
Sodium	1.8			1.9	1.8	2.2
Manganese	0.1			0.008	0.009	0.008
Copper				0.006	0.005	0.006
Sulfate	15	11	14	20	18	22
Chloride				0.6	0.49	0.39
Phosphate				0.02	0.033	0.059
Silicon Dioxide	6.0			3.8	3.2	3.9
Alkalinity:						
Phenolphthalein				1	1	1
Methyl Orange	59			56	58	60

Other general constituents (27):	Parts per Million (except pH)		
	Average	Maximum	Minimum
Turbidity	10	>100	3
NH_3	0.02	0.18	0.00
NO_2	0.01	0.06	0.00
NO_3	0.54	0.20	0.00
BOD	0.41	1.3	0.00
DO	10.9	16.1	8.3
pH	8.3	8.7	7.5

Mt. Adams and Mt. St. Helens in Washington and Mt. Hood in Oregon are entirely within the Basin. Through the Cascade Mountain range the river has eroded a picturesque channel known as the Columbia Gorge.

The chief industries—farming, lumbering, manufacturing, power production and fisheries—are dependent upon the Columbia River. About one-half the area is forested, with a great portion containing stands of sawtimber.

Manufacturing consists principally of processing wood, food, metal and textiles. Principal plants of note along the river are four pulp mills and three aluminum reduction works, with a fourth just starting operations. These reduction mills represent a very significant portion of the nation's primary aluminum capacity.

Recreational opportunities in the lower Columbia drainage area are diversified and great. The area is rich in natural beauty and northwest history and attracts many visitors. Fishing, hunting, picnicking, boating, camping, swimming, mountain climbing and winter sports are readily available to people living in the area and to visitors. Winter sports are an important part of recreational activity. The monetary value of recreation in the area is as important as income from other major industries. Water-borne commerce and commercial fishing in the lower stretch of the river are of great economic importance. Commerce on the river is increasing and will continue to increase as current and proposed water resource development projects are completed.

Water resources in the area supply the domestic needs of some 600,000 people, including over 400,000 living in the vicinity of Portland. Almost one-half million acres of land are irrigated. Extensive use is made of water for industrial water supplies. Ocean going vessels transport commodities on the Columbia River between the mouth of the river and the Vancouver-Portland area. Barge transportation between the latter area and Pasco, Washington is firmly established. There are three very important Federal hydroelectric power developments on this stretch of the Columbia—Bonneville Dam, The Dalles Dam and McNary Dam. There are also several sizeable private power developments on the Klickitat, Lewis and Cowlitz Rivers in Washington and on the Deschutes River in Oregon, all tributary to the lower Columbia.

Table II is a summation of the principal sanitary and industrial wastes recorded for this portion of the Columbia in terms of population equivalents.

TABLE II

COLUMBIA RIVER

(Mouth to Yakima River, Mile 335)
Estimated Population Equivalent Discharged to Stream

	Municipal	Industrial	Total
Oregon	284,600	978,000	1,262,600
Washington	111,000	3,500,000	3,611,000
Total	395,600	4,478,000	4,873,600

The water pollution control program for the basin has two principal objectives.(13) These are (1) to preserve the present high quality of water in unpolluted streams consistent with reasonable and beneficial future developments; and (2) to restore polluted waters to a level of quality suitable for

present and foreseeable future use. The abatement and control of water pollution from municipal and industrial sources will restore waters now polluted to a level of quality suitable for present and future usage. It will still be necessary, however, for agricultural and forestry interests to prevent deterioration of the present quality of the water in many unpolluted streams.

Over a period of some 15 to 20 years pollution conditions have been revealed by stream surveys along the lower Columbia River. These conditions have resulted from bacterial contamination due to discharge of sewage wastes and from a heavy growth of the organism Sphaerotilus natans which is stimulated by the discharge of large quantities of wood sugars from pulp mills. Organic wastes with high oxygen demands have only a minor effect on this reach of the river because of the magnitude of flow and the good reoxygenation characteristics. Damages due to toxic substances remain largely undetermined, but the great volume of flow in the river is believed to dilute such wastes to acceptable limits for present or contemplated stream uses.

Growth of Sphaerotilus, or slimes, which interfere with commercial fishermen's nets and gear and increase the hazards of handling logs in booming areas are found below the pulp mills at Camas, Vancouver, and Longview, Washington. When growths are heavy large segments break off and float downstream, thus causing damage considerably beyond their areas of growth. Slime growths are also produced in the Willamette River, however much of the sloughed material settles in Portland harbor.

The Washington Pollution Control Commission in 1954 reported that an investigation of pollution of the lower Columbia River indicated a "background concentration" of 15 to 20 ppm of apparent sulfite waste liquor in the Columbia River immediately above the Weyerhaeuser mill at Longview. This background concentration was a composite of all sulfite waste liquors introduced into the Columbia River by mills along the main stem and on the Willamette.

The Weyerhaeuser Timber Company has installed a magnesia base sulfite process in its pulp mill at Longview, Washington. This installation, the first of its kind, marks an important advance in stream pollution prevention. Use of the process permits recovery of most of the wastes from a sulfite mill.

Of the various nutrients required for Sphaerotilus growth, those introduced by irrigation return flows, industries and pulp mills are the most important. Mineral nutrients have increased since the Columbia Basin irrigation project was placed in operation. The sulphate content of the river below this project has almost doubled, and the phosphate concentration has increased almost three-fold since the project was placed in operation.(10) These nutrients and those found in sulfite waste liquor along with proper conditions of temperature and velocity of flow, have apparently caused the aggravation of the slime problem found in the lower Columbia River. It has been repeatedly observed that this problem occurs within the basin only below waste outlets which provide carbohydrate nutrients such as those from pulp mills and food processing plants.

At the request of the States of Washington and Oregon the Surgeon General of the Public Health Service, under provisions of the Federal Water Pollution Control Act, has called a conference on pollution of the lower Columbia River (below Bonneville Dam). Conferences and participants whom they invite will meet in September, 1958 for purpose of presenting information on waste discharged to the lower Columbia, steps being taken to correct pollution conditions and a time table which may be followed in a corrective program the Conference may find necessary.

Table III[10] indicates radioactivity at various points in the Columbia River below the Hanford works since 1951.

TABLE III

TREND OF COLUMBIA RIVER RADIOACTIVITY

Year	Concentration of Gross Beta Emitters - Units of 10^{-8} uc/cc		
	Pasco-Kennewick	McNary - Paterson	Arlington - Portland
1951	99	34	-- < 5
1952	141	45	-- < 5
1953	212	43	16 to 4
1954	175	28	12 to 4
1955	216	38	32 to 4
1956	300	36	28 to 6
1957 (3Q's)	508	70	75 to 20

Public Health Service Basic Data Program and Its Application in the Columbia River Basin

Under the Federal Water Pollution Control Act the Public Health Service is responsible for securing basic data on water quality[15] and is establishing a network of sampling stations, many of which are already in operation. Six stations have been designated for the Columbia River system. One of these is located on the lower Columbia River in the vicinity of Longview, Washington. A second at Bonneville Dam was established approximately a year ago through the cooperation of the U. S. Corps of Engineers and with the laboratory assistance of the Oregon State Board of Health. At the present time it is being operated with the active cooperation and assistance of the Crown Zellerbach Company at Camas, Washington. A third station, in operation at Pasco, Washington, is being serviced by the city of Pasco's engineering department and some of the analyses are made by the city water superintendent in the laboratory of the Pasco water filtration plant. Another station is to be located in the vicinity of Wenatchee. The exact location of this station is presently being studied. A station located at Wawawai, Washington, on the Snake River, is being operated by Washington State College, Pullman, Washington. The sixth station for the basin is in operation on the Snake River at Weiser, Idaho. Following are some of the results obtained to date from the basic data stations at Pasco, Washington, and Bonneville Dam, Oregon: Tables V and VI.

In 1952, the Pollution Control Council, Pacific Northwest Area, adopted Water Quality Objectives,[17] which are used by the States throughout the Columbia Basin in determining needs for pollution control and prevention. Their use by the State Water Pollution Control agencies has been found to be very helpful and their application throughout the basin is now widespread. The Foreword and Statement of Policy found in these objectives adopted by the Council are quoted below:

TABLE IV (16)

Results of Radioactivity Determinations Bonneville Pool - 1952
(The AEC Hanford Works is above River Mile 340)

Distance from North Shore	Date 1952	Gross Beta Activity Density uuc/l Upper End (The Dalles) River Mile 191	Center Pool River Mile 167	Lower End (Bonneville Dam) River Mile 150
1/4 (at surface)	8/20	220	120	80
	8/25	270	150	90
	8/27	320	180	110
1/2 (at surface)	8/20	220	120	70
	8/25	290	140	100
	8/27	320	180	100
3/4 (at surface)	8/20	230	80	90
	8/25	260	130	90
	8/27	290	150	120
Medians		270	140	90

(Water Quality Studies in the Columbia River, 1954 p D-24)

"The Pacific Northwest is at present in an enviable position as regards its natural resources and potential development when compared with many other areas of this country. This is especially true of natural waters which are admittedly one of the area's greatest assets. Water is so definitely tied in with the health, welfare and pleasure of citizens and with the whole economic structure of the area as to make high water quality objectives not only desirable but imperative.

"A similar position was held by many areas of this country during the past years. The development of these areas without regard to the implications of pollution has resulted in many cases in the loss of the waterways and streams for any use except the disposal of sewage and wastes. The water essential to growth and to effective living has been dissipated by carelessness and lack of foresight. Water is a factor which can well limit the development of all areas of the country and therefore water pollution control in the Pacific Northwest becomes a conservation and prevention program. Certainly we in the Pacific Northwest should profit by the mistakes of others and establish high objectives for the waters of the area and apply such objectives with judgment and especially with a view to future development.

TABLE V
WATER QUALITY BASIC DATA PROGRAM

STATION Columbia River at Bonneville, Oregon

Date (1957)	COLIFORMS MPN per 100 ml.	RADIOACTIVITY uuc/liter RAW WATER Alpha	RAW WATER Beta	Sample - Gallons	CAR TOTAL MATERIALS EXTRACTED	CAR Alcohol Extracts	CAR Ether Insolubles
2-13	40(1)	0.6	240	4870(2)	127	103	0
3-15	70(1)	1.4	439	6300(3)	152	105	-
4-15	45(1)	5.6	294	6761(4)	113	91	<1
5-23	45(1)	2.1	120	6891(5)	88	48	<1
7-2	40(1)	0.5	270	6007(6)	145	113	Trace
8-5	8(1)	0.0	442	3315(7)	248	200	1
9-16	15(1)	2.3	326	10614(8)	60	46	--

(1) Average of weekly samples collected during month shown
(2) Collected 2/5/57 to 2/13/57
(3) Collected 3/5/57 to 3/15/57
(4) Collected 4/3/57 to 4/15/57

TABL E V
ATA PR OGRAM - LABORATORY RESULTS

CAR BON FILTER EXTRACTS

MATERIALS EXTRACTED - PARTS PER BILLION

CHLOROFORM EXTRACTS

Insolubles	Water Solubles	NEUTRALS					Weak Acids	Strong Acids	Bases	Loss	TOTAL
		TOTAL	Aliphatics	Aromatics	Oxygenated Compounds	Loss					
0	3	14	4	2	7	2	2	<1	<1	3	24
-	11	15	1	<1	12	1	5	2	1	14	47
<1	5	7	1	<1	5	1	3	2	<1	4	22
<1	10	8	1	1	4	2	4	4	2	13	40
race	8	10	2	1	7	<1	3	1	1	9	32
1	11	12	2	<1	8	2	5	5	<1	12	48
--	2	5	<1	<1	3	<1	2	3	2	1	14

hown

(5) Collected 5/13/57 to 5/23/57
(6) Collected 6/19/57 to 7/2/57
(7) Collected 7/22/57 to 8/2/57
(8) Collected 9/3/57 to 9/16/57

TABLE V (Continued)
WATER QUALITY BASIC DATA PROGRAM - LABORATORY

STATION Columbia River at Bonneville, Oregon

Date (1957)	PLANKTON: ALGAE /ml										
	BLUE GREEN		PIGMENTED FLAGELLATES			GREEN			DIATOMS		TOTAL
	Coccoid	Filamentous	Green	Brown	Other	Coccoid	Filamentous	Miscellaneous	Centric	Pennate	
2-13	0	0	0	0	0	10	0	0	3650	340	4000
3-15	0	0	0	0	0	0	0	0	290	630	920
4-15	0	0	0	0	0	10	0	0	190	430	630
5-23	0	0	0	0	0	0	0	0	1000	3140	4140
7-2	0	10	0	0	0	100	0	0	3280	1240	4630
8-5	0	240	0	20	0	420	0	0	1240	2740	4660
9-16	0	0	40	0	0	150	0	0	2110	1370	3670

(Con tinued)
RAM - LABORATORY RESULTS, Continued

A N K	T O N									
		PROTOZONA/100 ml								
TOTAL		Flagellates (unpigmented)	Ciliates	Cysts	Others	Rotifers /100 ml	Crustacea /100 ml	Worms /100 ml	Dominant Organisms	Interference Organisms
4000		0	0	0	0	0	10	0	Cyclotella	Cyclotella
920		0	10	0	0	10	0	0	Navicula Cyclotella	-
630		0	10	0	0	10	0	0	Asterionella Cyclotella	Diatoms
4140		0	0	0	0	0	0	0	Navicula Cyclotella	Asterionella
4630		0	200	0	0	200	0	0	Cyclotella Asterionella	Cyclotella Asterionella
4660		0	10	60	0	70	0	0	Asterionella Synedra	Asterionella Synedra
3670		0	0	100	0	50	0	0	Cyclotella Synedra	Cyclotella Synedra

TABLE V (Conclud
WATER QUALITY BASIC DATA PROGRAM - LAB

STATION Columbia River at Bonneville, Oregon

Date	MPN Coli-forms 100/ml	RADIOACTIVITY, uuc/l						Temp. °C.	D.O. mg/l	PH	B.O.D. mg/l	C.O.D. mg/l
		Alpha			Beta							
		Susp. A	Dis. A	Total A	Susp. B	Dis. B	Total B					
11/57												
11					50	243	293					
18	x		1	1	25	348	373	9.5	11.4	8.0	1.8	x
25	x		2	2	14	482	496	9.0	11.4	7.8	1.2	x
12/57												
2	80				36	578	614	7.5	11.7	8.1	1.2	x
9	x				37	552	589	6.5	11.6	8.1	1.3	x
16					38	370	408	6.0	11.6	8.1	1.2	x
23			1	1	27	388	415	5.5	11.9	8.1	2.2	x
30			2	2	33	387	420					
1/58												
6	7		1	1	3	345	348	3.5	13.0	8.1	1.1	13.5
13	7		1	1	67	545	612	4.0	12.6	8.1	1.0	4.0
20	x				64	465	529	4.5	12.4	8.1	.7	x
27	1				41	276	317	5.5	12.5	7.9	.8	2.8
2/58												
3	90				52	432	484	6.0	12.0	7.9	1.1	9.7
10	10		2	2	50	510	560	6.5	11.8	7.8	1.0	2.3
17	220		2	2	54	321	375	7.0	12.1	7.5	1.1	10.0
24	110				70	237	307	7.5	12.3	7.8	1.1	x
3/58												
3	60	1		1	58	273	331	7.5	12.6	7.9	1.0	x
10	940	1	1	2	60	252	312	6.0	13.0	7.9	1.2	5.7
17					46	131	177	6.0	12.5	7.8	1.1	6.9
24	40				47	268	315	7.0	12.3	8.2	1.4	4.7
31	28		3	3	100	416	516	8.5	12.2	8.2	1.2	4.4
4/58												
7					61	272	333	9.0	11.5	8.0	.9	13.5
14	50				70	296	366	11.0	11.0	8.0	.9	8.1
21					66	239	305	10.0	11.4	8.0	1.4	x
28	110				32	161	193					
5/58												
5	20				78	198	276					

LE V (Concluded)
PROG AM - LABORATORY RESULTS, Concluded

.O.D. g/l	C.O.D. mg/l	Chlorine Demand mg/l 1 hr.	Chlorine Demand mg/l 24 hrs.	NH_3-N mg/l	Cl. mg/l	Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Color Scale Units	Turb. Scale Units	Total Dissolved Solids mg/l
1.8	x	x	x	x	4	77	x	x	5	x
1.2	x	x	x	x	6	78	x	x	5	x
1.2	x	x	x	x	6	78	x	x	5	x
1.3	x	x	x	x	5	73	90	x	5	x
1.2	x	.7	1.3	.19	5	74	92	x	5	143
2.2	x	1.1	1.3	.25	8	74	99	x	x	155
1.1	13.5	1.2	1.3	.20	8	74	93		2	140
1.0	4.0	1.6	2.7	.18	6	73	89		4	150
.7	x	.5	1.7	.25	8	73	123		3	150
.8	2.8	.8	x	.18	8	72	131		5	124
1.1	9.7	x	x	.26	x	x	x	5	86	140
1.0	2.3	x	x	x	x	x	x	3	25	124
1.1	10.0	1.5	2.3	.14	3	74	178	8	105	164
1.1	x	2.2	2.3	.35	4	67	180	11	88	140
1.0	x	.9	2.9	.30	2	63	160	9	54	140
1.2	5.7	.3	x	x	2	65	142	4	45	176
1.1	6.9	.2	1.2	x	3	72	145	1	6	128
1.4	4.7	.5	2.0	.50	3	71	178	2	5	128
1.2	4.4	.8	.8	.24	3	76	150	4	20	136
.9	13.5	1.1	2.5	.04	3	69	163	5	10	120
.9	8.1	.7	1.2	.10	3	67	138	5	35	136
1.4	x	1.1	3.3	.28	3	61	124	5	41	144

WATER QUALITY BASIC DATA

STATION Columbia River, Pasco, Washington

Date	MPN Coli-forms 100/ml	RADIOACTIVITY, uuc/l						Temp. °C.	D.O. mg/l	PH	B.O.D. mg/l	C.O.D. mg/l
		Alpha			Beta							
		Susp. A	Dis. A	Total A	Susp. B	Dis. B	Total B					
11/57												
4	x				45	831	876	13.3	x	8.2	x	
11								13.3	x	8.2	x	x
18	x		1	1	10	829	839	12.2	x	8.2	x	x
25	60				26	783	809	12.2	x	8.0	x	x
12/57												x
2	24				50	1212	1262	10.0	9.9	8.1	x	
9	120				83	1301	1384	9.5	10.7	8.1	x	x
16	70		1	1	81	1521	1602	9.5	10.0	8.1	x	x
23			3	3	66	547	613	8.9	10.2	8.1	x	x
30					165	2698	2863	7.8	10.6	8.1	x	x
1/58												x
6	46				58	57	155	7.2	10.8	8.1	1.6	
13	80		1	1	91	1427	1518	6.7	10.8	8.1	1.6	x
20	40		1	1	98	1645	1743	6.7	11.1	8.1	1.8	x
27	4800		1	1	99	1440	1593	7.8	10.6	8.1	1.6	x
2/58												x
3					113	1330	1443	7.8	10.3	8.1	1.4	
10	63		14	14	61	960	1021	7.2	10.8	8.1	1.7	x
17			1	1	94	913	1007	6.7	10.8	8.0	1.7	x
24	26				173	1070	1243	7.8	11.1	8.2	2.6	x
3/58												x
3								6.7	11.7	8.0	2.7	
10	26		1	1	43	670	713	6.7	x	8.0	x	x
17								6.1	11.8	8.1	2.4	x
24								7.8	11.1	8.0	2.0	7.2
31								7.8	11.1	8.0	2.0	x
4/58												x
7	84	x	x	x	99	890	989	8.9	10.8	7.9	2.6	
14		x	x	x	241	541	782	10.0	10.8	8.0	1.6	x
21	30	x	x	x	x	x	x	10.8	10.8	7.9	1.8	x
28	13	x	x	x	38	404	442	10.0	11.0	8.1	2.0	7.0
5/58												x
5								11.0	11.0	8.1	1.6	
12								13.0	10.3	8.0	1.3	x
19								12.0	9.0	7.9	1.0	x
												x

BLE VI
PROGRAM - LABORATORY RESULTS

C.O.D. mg/l	Chlorine Demand mg/l		NH_3-N mg/l	Cl. mg/l	Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Color Scale Units	Turb. Scale Units	Total Dissolved Solids mg/l
	1 hr.	24 hrs.							
x	x	x	x	x	60	70	5	1	
x	1.0	1.5	x	x	60	72	5	6	
x	.8	1.0	x	x	59	76	5	1	
x	.8	1.5	x	x	62	74	5	1	
x	.5	1.0	x		63	74	4	1.2	
x	1.0	1.0	x		61	79	3	1	
x	.5	1.0	x		65	83	5	3	
x	.5	1.0	x		61	76	5	4	
x	.8	1.0	x		62	79	4	4	
1.6									
1.6	x	.8	.8	x		64	80	3	2	x
1.8	x	.8	.8	x		63	78	5	4	x
1.6	x	.5	.8	x	x	60	80	5	2	x
	x	.5	1.0	x		65	79	3	3	x
1.4									
1.7	x	.8	1.3	x		61	80	4	3	x
1.7	x	.8	1.3	x		64	80	5	3	x
2.6	x	.5	1.0	x		77	82	3	5	x
	x	.8	1.0	x		62	82	6	6	x
2.7									
x	x	.8	1.0	x		60	80	5	5	x
2.4	x	.8	1.0	x		78	84	3	4	x
2.0	7.2	1.0	1.8	x		68	82	5	8	x
2.0	x	1.3	1.3	x		62	81	9	13	x
	x	1.0	1.0	x		68	78	6	7	x
2.6									
1.6	x	1.5	1.8	x		62	78	5	12	x
1.8	x	1.0	1.5	x		61	79	5	5	
2.0	7.0	.8	1.3	x		58	78	3	3	x
	x	1.35	1.5	x		61	76	12	5	x
1.6										
1.3	x	1.5	1.85	x		61	80	12	4	x
1.0	x	1.5	1.8	x		60	78	5	4	x
	x	1.35	1.75	x		57	68	12	10	x

"It is hereby declared to be the policy of the Pollution Control Council of the Pacific Northwest Basins to encourage and promote programs for the preservation of the surface and ground waters of the basins and the restoration of such waters to the best possible condition consistent with the Public Health and Welfare, the propagation and protection of fish and wildlife, and the domestic, recreational, agricultural, and industrial development of the area.

"Whereas it is recognized that many waters of the basin have not yet been adversely affected by industrial, agricultural, or domestic development and, therefore, are of the highest possible quality, one objective of any water conservation program should be to preserve these waters in the best condition consistent with reasonable and beneficial future development.

"Whereas it is also recognized that other waters in the basin now exist at a level of quality below that which is necessary and desirable for the best interest of the people, a second objective should be to restore these waters to conditions permitting increased beneficial uses by the people of the area."

Water Quality Objectives and Minimum Treatment Requirements which accompany these objectives will be found in Fig. 3.

Also in 1952, the Pollution Control Council adopted "Minimum Requirements for Prevention of Industrial Waste Pollution".(18) These requirements now have the status of regulations for prevention of Industrial Waste Pollution in some States in the Columbia River Basin. The following is the introduction to this document:

"Pollution by wastes from industry exceeds by many times that resulting from domestic sewage. One of the reasons for this high pollution load is the lack of understanding on the part of certain industrial management of the effects of industrial pollution. Much of the load contributed by industry can be eliminated by careful operations and comparatively inexpensive waste prevention measures. Waste saving measures have been known to result in profit to certain industries. The true value of these measures, however, is in the reduction of the pollution load on public waters or on the operation load applied to municipal sewage treatment facilities in case the industry has access to the municipal system.

"These minimum requirements are designed to bring about more careful industrial operation and to promote waste prevention. To be of most value they must be applied on an industry-wide basis and as such will constitute a fair and reasonable means of reducing industrial pollution. It is expected that in some cases these measures will not be sufficient to solve a pollution problem and that further reduction by waste treatment will be necessary."

In 1956 a document dealing with "Water Supply and Watershed Protection"(19) was adopted by the Council. The following quotation from the document briefly states its purpose and contents:

"The purpose of this document is to point out how the use of various control measures and management practices and watersheds will

conserve the water resources and prevent economic losses to municipal, industrial and agricultural water supplies, fisheries and recreation. It summarizes water supply and quality requirements for the various uses in the Pacific Northwest, indicates how lack of adequate control measures and management practices adversely affects these uses, and includes recommendations for improvements in watershed protection and management.

"It is primarily the upper watersheds that are considered in the document. However recommendations included for construction of roads and railroads and for agricultural activities are applicable to the lower as well as the upper portions of watersheds. Some of the watersheds in the Pacific Northwest still are in their virgin state and yield water of high quality; some have been so modified by various activities that they now yield contaminated or turbid water. Continued economic progress will necessitate extending resource developments into the upper reaches of all watersheds and utilizing more extensively the resources in presently developed areas of the Pacific Northwest. In the utilization and development of the land and water resources Federal and State agencies and private enterprises should consider it their responsibility to: (1) preserve the excellent quality of water in presently undeveloped areas; and (2) help restore the quality of water in other areas to conditions permitting increased beneficial uses".

Dr. LeRoy Burney, Surgeon General, U. S. Public Health Service, recently made the following statement:*

"The nation's growing population and expanding industry must have good water and the areas with good water will show the greatest economic growth.

"The factors with which we evaluate pollution control at present may not be the most sensitive. For example, I have often wondered, in reading reports on pollution control: Does the number of treatment plants constructed or the percentage of the population served by treatment give us an adequate measure of progress? Is it not true that a stream can be deteriorating despite these improvements? Do we not need a more definite measure of water quality itself?

"Perhaps this is one of the sources of misunderstanding with conservationists and citizen groups concerned with recreation and public health. We measure progress by what we have built. They measure the lack of progress in oil slicks, scum, foul odors, poor fishing, and "No Swimming" signs".

Mark D. Hollis, Assistant Surgeon General and Chief Engineer of the U. S. Public Health Service, recently stated that:**

"The outstanding work accomplished in pollution abatement simply has been out-distanced by the speed of progress and the development of

*Statement made in a talk presented at a conference of State and Interstate Water Pollution Control Administrators with the Surgeon General, February 19, 1958.

**Statement made in a talk presented at a conference of State and Interstate Water Pollution Control Administrators with the Surgeon General, February 19, 1958.

FIGURE 3. WATER QUALITY OBJECTIVES

WATER QUALITY ↓ / WATER USES →	WATER QUALITY OBJECTIVES, APPLICABLE TO RECEIVING WATERS: ORGANISMS OF THE COLIFORM GROUP	FLOATING, SUSPENDED & SETTLEABLE SOLIDS & SLUDGE DEPOSITS	TASTE-OR ODOR-PRODUCING SUBSTANCES
A. WATER SUPPLY, DRINKING, CULINARY & FOOD PROCESSING WITHOUT TREATMENT OTHER THAN SIMPLE DISINFECTION AND REMOVAL OF NATURALLY PRESENT IMPURITIES	MOST PROBABLE NUMBER COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 50 PER 100 ML. IN ANY MONTH	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES OR OTHER WASTES OR WHICH, AFTER REASONABLE DILUTION & MIXTURE WITH RECEIVING WATERS, INTERFERE WITH THE BEST USE OF THESE WATERS FOR THE PURPOSE INDICATED	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES
B. WATER SUPPLY, DRINKING, CULINARY & FOOD PROCESSING WITH TREATMENT EQUAL TO COAGULATION, SEDIMENTATION, FILTRATION, DISINFECTION AND ANY ADDITIONAL TREATMENT NECESSARY FOR REMOVING NATURALLY PRESENT IMPURITIES	M.P.N. COLIFORM BACTERIAL CONTENT WHEN ASSOCIATED WITH DOMESTIC SEWAGE OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 2000 PER 100 ML. AND SHOULD NOT EXCEED THIS NUMBER IN MORE THAN 20 PER CENT OF SAMPLES EXAMINED IN ANY MONTH	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXTURE, WILL INCREASE THE THRESHOLD ODOR NUMBER ABOVE EIGHT (8)
C. BATHING, SWIMMING AND RECREATION NOTE: WHEN WATERS ARE USED FOR RECREATIONAL PURPOSES SUCH AS FISHING & BOATING, EXCLUSIVE OF BATHING & SWIMMING, THE NUMBER "1000" MAY BE SUBSTITUTED FOR "240" IN STATEMENT OF COLIFORM OBJECTIVE	COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 240 PER 100 ML. AND SHOULD NOT EXCEED THIS NUMBER IN MORE THAN 20 PER CENT OF SAMPLES EXAMINED WHEN ASSOCIATED WITH DOMESTIC SEWAGE (SEE NOTE UNDER "C" AT LEFT)	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXTURE, WILL INTERFERE WITH THE BEST USE OF THESE WATERS FOR THE PURPOSE INDICATED
D. GROWTH & PROPAGATION OF FISH, SHELLFISH & OTHER AQUATIC LIFE	COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD NOT HAVE A MEDIAN CONCENTRATION GREATER THAN 70 PER 100 ML. IN WATERS USED FOR THE GROWTH & PROPAGATION OF SHELLFISH	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL INTERFERE WITH THE MARKETABILITY OR PROPAGATION OF RECREATIONAL OR COMMERCIAL FISH, SHELLFISH, OR OTHER EDIBLE AQUATIC FORMS
E. AGRICULTURAL AND INDUSTRIAL WATER SUPPLY WITHOUT TREATMENT EXCEPT FOR THE REMOVAL OF NATURAL IMPURITIES TO MEET SPECIAL QUALITY REQUIREMENTS, OTHER THAN THOSE CLASSIFIED UNDER "A" ABOVE. NOTE: FOR AGRICULTURAL WATER SUPPLY, SALINITY AND SODIUM HAZARDS ARE DETERMINED BY ELECTRICAL CONDUCTIVITY (EC x 10^6) AND SODIUM ADSORPTION RATIO (SAR). WATERS HIGH IN BOTH SALINITY AND SODIUM ARE GENERALLY UNSUITABLE FOR IRRIGATION PURPOSES. (SEE "CLASSIFICATION AND USE OF IRRIGATION WATERS", CIRCULAR NO. 969, U. S. DEPARTMENT OF AGRICULTURE, NOVEMBER, 1955)		SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL ADVERSELY AFFECT THE MARKETABILITY OF AGRICULTURAL OR INDUSTRIAL PRODUCE

AND MINIMUM TREATMENT REQUIREMENTS

...G WATERS, FOR SALT AND FRESH SURFACE WATERS AND UNDERGROUND WATERS						
DISSOLVED OXYGEN	pH	TOXIC, COLORED, OR OTHER DELETERIOUS SUBSTANCES	PHENOLIC COMPOUNDS	OIL	HIGH TEMPERATURE WASTES	MINIMUM TREATMENT REQUIREMENTS FOR DOMESTIC SEWAGE
...GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.5 & 8.5	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES IN SUFFICIENT AMOUNTS OR OF SUCH NATURE AS TO MAKE RECEIVING WATER UNSAFE OR UNSUITABLE FOR USE INDICATED (U.S.P.H.S. STDS.)	LESS THAN FIVE (5) PARTS PER BILLION	NONE	NOT IN SUFFICIENT QUANTITIES ALONE OR IN COMBINATION WITH OTHER WASTES TO INTERFERE WITH THE USE INDICATED	SEDIMENTATION AND EFFECTIVE DISINFECTION
...GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	SAME AS FOR USE "A" ABOVE	SAME AS FOR USE "A" ABOVE	LESS THAN FIVE (5) PARTS PER BILLION	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES AS TO MAKE RECEIVING WATER UNFIT OR UNSAFE FOR THE USE INDICATED	SAME AS FOR USE "A" ABOVE	SEDIMENTATION AND EFFECTIVE DISINFECTION
...GREATER THAN FIVE (5) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	SAME AS FOR USE "A" ABOVE	LESS THAN 25 PARTS PER BILLION OR NONE IN SUFFICIENT AMOUNTS SUCH AS TO IMPART A RESIDUAL TASTE TO RECREATIONAL OR COMMERCIAL FISH, SHELLFISH, OR OTHER AQUATIC FORMS	SAME AS FOR USE "B" ABOVE	SAME AS FOR USE "A" ABOVE	SEDIMENTATION AND EFFECTIVE DISINFECTION
...GREATER THAN SIX (6) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES TO SUFFICIENT AMOUNT OR OF SUCH CHARACTER AS TO MAKE RECEIVING WATERS UNSAFE OR UNSUITABLE FOR USE INDICATED	SAME AS FOR USE "C" ABOVE	SAME AS FOR USE "B" ABOVE	NONE IN SUFFICIENT QUANTITY AS TO BE INJURIOUS TO OR INTERFERE WITH THE NORMAL PROPAGATION OF FISH, SHELLFISH, OR OTHER AQUATIC LIFE	SEDIMENTATION FOR ALL USES UNDER THIS GROUP BUT DISINFECTION REQUIRED IN ADDITION ONLY IF DISCHARGED INTO WATERS USED FOR THE GROWTH & PROPAGATION OF SHELLFISH, EITHER COMMERCIAL OR RECREATIONAL
...GREATER THAN THREE (3) PARTS PER MILLION	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.0 & 9.5	SAME AS FOR USE "A" ABOVE	NONE IN SUFFICIENT QUANTITY AS TO MAKE RECEIVING WATER UNSUITABLE FOR USE INDICATED	SAME AS FOR USE "B" ABOVE	SAME AS FOR USE "A" ABOVE	SEDIMENTATION AND EFFECTIVE DISINFECTION

Adopted by
POLLUTION CONTROL COUNCIL
PACIFIC NORTHWEST AREA
May 1952
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2nd Revision
3rd Revision

new problems—at the present level of remedial actions the situation is destined to get worse—not better.---Perhaps our greatest single problem today is to close the gaps in scientific knowledge with respect to the behavior of new contaminants in streams, and their effects on aquatic life and on municipal and industrial water supplies --- In summary, may I emphasize and re-emphasize the need to step up our research effort. On this there is no question about the great sense of urgency".

The basic philosophy carried out by Water Pollution Control agencies responsible for these programs in the Pacific Northwest has been one of prevention rather than one geared to correction alone. The Willamette River, however, is an example of an area where a corrective pollution control program has been instituted. As a result, progress is being made in re-establishing anadromous fish runs in the river. Actually the standards established for the critical areas such as Portland harbor have been based on requirements of migrating anadromous fish.

CONCLUSIONS

The Columbia River Basin is young. The first settlement was established within the area less than 150 years ago. Since that time and especially during the past 100 years development within the basin has been rapid. There are great possibilities for future development. Since the Columbia River is the Basin's greatest natural resource it is extremely important that the river be used and developed in such a way that the inevitable expansion can take place without creating conditions that will jeopardize still further growth.

Of all the rivers in the United States the Columbia is one of the most important for multiple use benefits, not only to the area but to the nation as well. The natural waste carrying capacity of the river must be utilized in a common sense way. It must be maintained in such condition that it can be used by municipalities and industries for water supplies, for hydro-electric power development, for navigation, fish and wildlife propagation, and for increasingly important recreational uses. It must also be used for carrying away treated wastes of communities and industries since necessary consequences of modern civilization are the wastes produced by that civilization. Wastes must be treated in such a way that their disposal into natural waterways will not interfere with other water uses. It should be incumbent upon municipalities and industries to support and aline themselves with these objectives in the interest of permitting their own growth and development.

The people of the Northwest are proud of the clean waters which exist in most of the area. At the same time they are disturbed about these areas in which water degradation has taken place to the point where other water uses such as municipal and industry water supplies and recreational use have been seriously impaired. In the foreseeable future quantities of water needed for municipal and industrial water supplies will increase many fold. The same can be said for recreation. As our civilization becomes more complicated recreation becomes more important. The Columbia River Basin is one of the few remaining areas in the country where recreational activities can increase because of the availability of natural waters of satisfactory quality and quantity.

There is an adequate quantity of water of good quality to sustain extensive industrial development, population growth, recreational development and other

legitimate water uses, provided a comprehensive water pollution control program is followed. Instead of loading streams to the limit of their waste carrying capacities the public, in the Pacific Northwest, is anxious that as much waste as possible be kept out of these waters.

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SED RESEARCH REPORT NO. 22

On An Evaluation of Two Recent Industrial Waste Treatment Processes

By Industrial Wastes Section of the Sanitary Engineering Research Committee

ABSTRACT

A brief discussion based on the data from two pilot plant studies on industrial waste treatment by recovery methods. The first covers a Process for the recovery of waste pickle liquor, and the second an atomized suspension technique, for an effective evaporation, drying, and chemical treatment sequence.

Process No. 1 - Pickling Liquor Waste Treatment

History

Seven steel companies and the Ohio River Valley Water Sanitation Commission joined forces to develop a pilot plant program for the recovery of waste pickle liquor. This was preceded by three years of study of a chemical process originally conceived by Othmar Ruthner of Vienna, Austria.

The Process

Iron oxide scale present on steel is removed by pickling in sulfuric acid.

$$FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$$

Scale-free steel is produced. The ferrous sulfate solution which is formed in the pickler is then concentrated and treated with hydrogen chloride gas

Note: Discussion open until October 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 2031 is part of the copyrighted Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. SA 3, May, 1959.

$$FeSO_4 + 2HCl \rightarrow FeCl_2 + H_2SO_4$$

The sulfate equivalent of the ferrous sulfate is recovered as re-usable sulfuric acid by a simple chemical reaction, thus eliminating the process from other previously proposed recovery schemes. Ferrous chloride is transferred to the furnace and roasted

$$FeCl_2 + H_2O \rightarrow FeO + 2HCl$$

In this manner, hydrogen chloride is recovered and recycled back to the reactor to complete the HCl cycle. Iron oxide passes out the bottom of the furnace and, when sintered may be charged back into the blast furnace, thus eliminating disposal or sale of any products from the process.

The Pilot Plant

The primary purpose of the pilot plant program was to prove the feasibility of the chemical and mechanical operations of the Blaw-Knox-Ruthner Process. The pilot plant program—which was estimated to cost $500,000—also had the objective of the collection of design data, testing of materials of construction, and the testing of alternate types of equipment so that optimum quality and economy of the process could be developed. The plant was so designed that exact prototypes of equipment that were available commercially were used.

Products

Reusable H_2SO_4 - 55-60%. $\overset{++}{Fe}$, 0.1%max. $\overset{-}{Cl}$, 1% max. $\overset{+++}{Fe}$ 0.5-1.0%
Reusable iron oxide - hematite and magnetite. Chloride 0.5% max. Sulfate 1.5% max.

Cost Analysis

After completion of the pilot plant program, the Blaw-Knox Company designed and estimated a commercial plant capable of treating 100,000 gallons per day of pickle liquor containing 8.5% free sulfuric acid and 13% ferrous sulfate. The following Table summarizes the cost comparison with the usual treatment of lime neutralization.*

Process	Ruthner	Lime Neutralization
Capital Cost		
Battery Limits	$3,634,000	
Off Sites	815,000	
Total Investment	$4,449,000	$900,000
Operating Costs, Annual		
Direct	$ 931,890	$886,650
Indirect	285,940	67,000
Total	$1,217,830	$953,650
Credits	766,334	-
Net Annual Cost	$ 451,496	$953,650
Cost per Gallon	$ 0.0129	$ 0.027

*Table from paper presented by J. H. Strassburger at May 1958 meeting.

Discussion and Evaluation

The overall pickling acid efficiency $\frac{\text{Recovered Acid}}{\text{Product Acid}}$ amounts to 82.15%. The Blaw-Knox-Ruthner efficiency, however, obtained by dividing the recovered acid in pounds per hour by the pickle liquor acid equivalent in pounds per hour, is 93.88%. The process—when treating 100,000 gallons of pickle liquor per day, results in a recovery of 12,000 tons per year of iron oxide and 54,800 tons per year of 56.6% H_2SO_4. It should be stressed that these progressive companies have developed a process which costs almost 30 per cent more per year to operate than the conventional existing process. However, returns as credits from the recovered by-products result in an overall cost of approximately 50% that of the lime neutralization process. Moreover, the recovered by-products are in constant demand by all plants in the steel manufacturing business. The recovered iron oxide may also be used as paint pigments or as a base material for making powdered iron. Since the Process is capable of handling high acid strength waste pickle liquor, the steel companies may wish to explore the advantages offered in high acid pickling operations. Any waste treatment process which cuts operating costs in half and results in no discharge of polluting liquors or gases is bound to serve as an accepted innovation for the industry.

Process No. 2 - Atomized Suspension Technique

History

Until recently, there existed no simple method of effecting evaporation, drying, and chemical treatment in sequence, in a single apparatus, which would at the same time fulfill all the major requirements of industrial feasibility. Even when performed in different pieces of equipment, the existing methods often presented a number of deficiencies, such as poor heat utilization and inadequate process control, or technological difficulties such as scaling and corrosion. When this new process was developed at the Institute in 1952, it appeared possible that its inherent simplicity and efficient heat recovery might make it particularly adaptable to the field of waste treatment, either for disposal or for chemical recovery. Intensive experimental studies carried out during the past five years have confirmed to the researchers these views.

The atomized suspension technique permits the evaporation and drying of a liquor of any initial concentration, followed by chemical treatment of the dried solids, if required, in a single pass through a single piece of equipment of very simple design.

The Reactor

The technique consists of atomizing the liquor or slurry to be treated into the top of a tower, the walls of which are maintained at an elevated temperature by means of hot gases circulating through a jacket. No air, or other foreign gas, is introduced in the equipment, which sharply distinguishes this technique from spray drying. In the immediate range of the nozzle, the finely divided droplets, of an average diameter of about 20-25 microns, quickly decelerate from the high initial velocity imparted by the atomizer to their slower terminal velocity. The droplets now become dispersed in the vapor

produced by their own evaporation, and the suspension thus created flows down the reactor in very nearly streamline motion. Owing to the large surface area available for heat and mass transfer and to the absence of gas-film resistance, evaporation—which was initiated in the nozzle range—is quickly completed and is followed by drying. At the end of the drying zone, the suspension of dried particles can now be subjected to a sequence of chemical reactions, such as oxidation, reduction, nitration, sulphonation, etc., through the injection of the proper gaseous reactants in the presence of a powdered catalyst, if necessary. Leaving the reactor at the bottom, the suspension consists, in general, of a solid residue (which is recovered in cyclone collectors), large amounts of steam (which is condensed and utilized) and by-product gases (which can be further processed for recovery, or led away for disposal).

The Pilot Plant

The reactor proper consisted of a tube of T-309 stainless steel, 10 feet in length, 8 inches in internal diameter, with 3/8 inch walls. Normal operating pressure is 30-50 psig and temperature about 1400° F. At least one Research Committee Member questions the "scale factor" here. These pressures and temperatures may not be so easy to maintain in large operations. Other design details are described in the papers.

Practical Applications

The researcher described two experimental applications conducted during the past two years. The first is concerned with a straight waste disposal system, whereas the second emphasizes both heat and chemical recoveries.

1. A pulp mill sludge was settled to 5% solids concentration, preheated in a heat exchanger, and concentrated to 13.5% in a small quintuple effect evaporator of standard design, and then to 23.2% in a cyclone evaporator of the type commonly used in kraft recovery plants, in direct contact with the hot flue gases at 1600° F., exhausted from the reactor combustion jacket. The sludge was then heated to 275° F. in a small heater and sprayed from a centrifugal-pressure atomizer in the reactor, maintained at a pressure of 30 psig with wall temperatures of 1400° F. Leaving the reactor, the solid residue is first separated in a cyclone separator, collecting at 95% efficiency, and the remaining mixture of superheated steam, pyrolysis gases, and uncollected solid residue fines is sent to the steam-chest of the evaporator first effect (operated at 25 psig) where the granular residue comes down with the condensate and drains away. The complete pilot operation is described in the papers. Although the capital cost of such a plant will probably be quite low because of its small size, the advantages to be derived from its operation are the elimination of a troublesome pollution and the complete reutilization of the water. Of more interest are treatment processes which, in addition, provide significant return in the form of chemicals, recovered heat, or process steam.
2. The researcher describes the treatment of a spent soda cooking liquor containing about 30% ash, from 16 to 18% total sodium, about 2% silica and less than 1% of iron and aluminum oxides. The total alkali ranges from 32 to 36%. The calorific value of the solids amounts to 6000 to 6500 BTU per pound. The liquor can be pumped and atomized easily up

to concentrations of 50% and higher.

Pilot-plant work indicated that the soda liquor could by pyrolyzed in in relatively short residence time—provided the walls were at a temperature of 750° C—to yield a solid residue of negligible combustible value, containing all the original sodium in the form of sodium carbonate (about 90%) and sodium oxide or hydroxide (about 10%). These sodium salts can be leached out with good efficiency (about 95%) and the residue filtered off to yield a clear, colorless filtrate. A pressure of 30 psig was used in these experiments.

Assuming a conservative sodium recovery of 90%, in the form of Na_2CO_3, the quantity of the latter recoverable per 8000 hour year amounts to 12,250 tons. At the low value of $31. per ton, a minimum credit of $380,000 per year for sodium carbonate can be estimated. To this should be added about $70,000 for recovered steam, if a rate of $0.65 per thousand pounds is assumed. Since very little electric power is required, the operating costs will consist mainly of labor, supervision, and maintenance, and should not exceed $50,000 per year. It is thus probable that the capital cost of this plant could be recovered in slightly less than 2 years.

Evaluation

Initial materials are recovered almost completely. Only spent low-temperature gases and ash are allowed to escape the otherwise closed system. It will be noticed that the various conversion steps are carried at successively decreasing temperature levels from 2700° F. down to that of the spent gases (which are lost) and of the condensates (which are utilized). More important still, full use is made of the latent heat, as well as of the sensible heat, of the various streams. The only outside energy required is that used for liquor pumping, which is almost negligible. A rather striking feature of the recovery flow-sheet is the complete absence of blowers or compressors, although large volumes of gases and vapors are continuously flowing through the system. Need for them is eliminated by the efficient utilization of the pressure generated in the reactor during evaporation.

Additional Investigations(4)

The researcher has also found that, by introducing a small amount of air, sewage sludge can also be atomized and completely oxidized within the small reactor (to 97% inorganic ash) in 3-1/2 to 5 seconds. These findings have influenced the design of a small sewage disposal plant for the Town of Beaconsfield, Quebec. The reactor will be preceded by a thickener which should deliver 10-12% solids. These results on sanitary sludge atomization should be available some time early in 1959.

ACKNOWLEDGMENT

Process No. 1: From data and information submitted by N. F. Boyd and T. F. Barnhart of the Blaw-Knox Company and a paper by J. T. Strassburger(1) of the National Steel Corporation.

Process No. 2: From research and pilot plant data and publications[2,3] of W. H. Gauvin, Head of Chemical Engineering Division, Pulp and Paper Research Institute of Canada, Montreal, Quebec.

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1. Paper read at General Meeting of American Iron and Steel Industries, New York, May 21, 1958.
2. Tappi 40, 11, 866-877, Nov. 1957.
3. Pulp and Paper Mag. Canada 59, 3, 140, March 1958.
4. Private letter communication of August 22, 1958.

Credit

This research report, which is one of a series of professional contributions by the Committee on Sanitary Engineering Research,

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RADIOACTIVE CONTAMINANT REMOVAL FROM WASTE WATER: ENGINEERING DESIGN FEATURES[a]

Mark C. Culbreath,[1] M. ASCE

ABSTRACT

The first of two papers relating to the design and operation of a plant at Oak Ridge National Laboratory on the collection, treatment, and disposal of large volume (0.5 - 0.7 mgd), low-level radioactive liquid waste. The paper covers the design of the lime-soda softening process treatment plant for the removal of strontium and the total rare earths from process waste water.

INTRODUCTION

So far as is known this plant, located at Oak Ridge National Laboratory, is the first full scale unit of this type adapted for treatment of low level radioactive wastes, particularly for the removal of strontium.

Design Criteria

It is required to reduce the radiation activity to a level that will not exceed the acceptable standards for discharge into White Oak Creek and the Clinch River.

1. Treatment Requirements:

The treatment plant conforms very closely to that of a standard water softening plant, having the usual water softening equipment and using the usual water softening chemicals. The plant was designed with the requirement that it would be possible to reduce the calcium carbonate content to 30 to 35 ppm

Note: Discussion open until October 1, 1959. Separate discussions should be submitted for the individual papers in this symposium. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 2032 is part of the copyrighted Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. SA 3, May, 1959.

a. Presented at the October 1958 ASCE Convention in New York, N. Y.

1. Principal Engr., Burns and McDonnell Engineering Co., Kansas City, Mo.

with a maximum of 50 ppm. Provision is made for feeding hydrated lime, soda ash, calcium chloride, clay and tri-sodium phosphate.

The plant influent will have a wide fluctuation in the pH value with a possible low of 2 and a possible high of 10.

The plant was designed with one treatment line capable of treating 500,000 gallons per day and so constructed that an additional treatment line of 500,000 gallons per day could be added at a later date.

The detention time, at nominal rate, in the three units of the treatment line are as follows:

Flash Mixer Basin	85 seconds
Coagulation Basin	31 minutes
Settling Basin	129 minutes

The overflow rate for the settling basin would be 695 gallons per square foot per day.

2. Plant Features:

Fig. 1 shows the general area of the plant with the equalization basin in the foreground, the control building and the treatment plant which are the three main features we will be discussing in this paper.

The settling basin in the middle left is one of several original holding basins. It is still being used for wastes that do not require treatment. All process waste water containing low level radioactive waste from the various laboratory processes is either discharged to this settling basin or to the equalization basin for treatment in the plant. White Oak Creek lies just beyond the settling basin and the treatment plant.

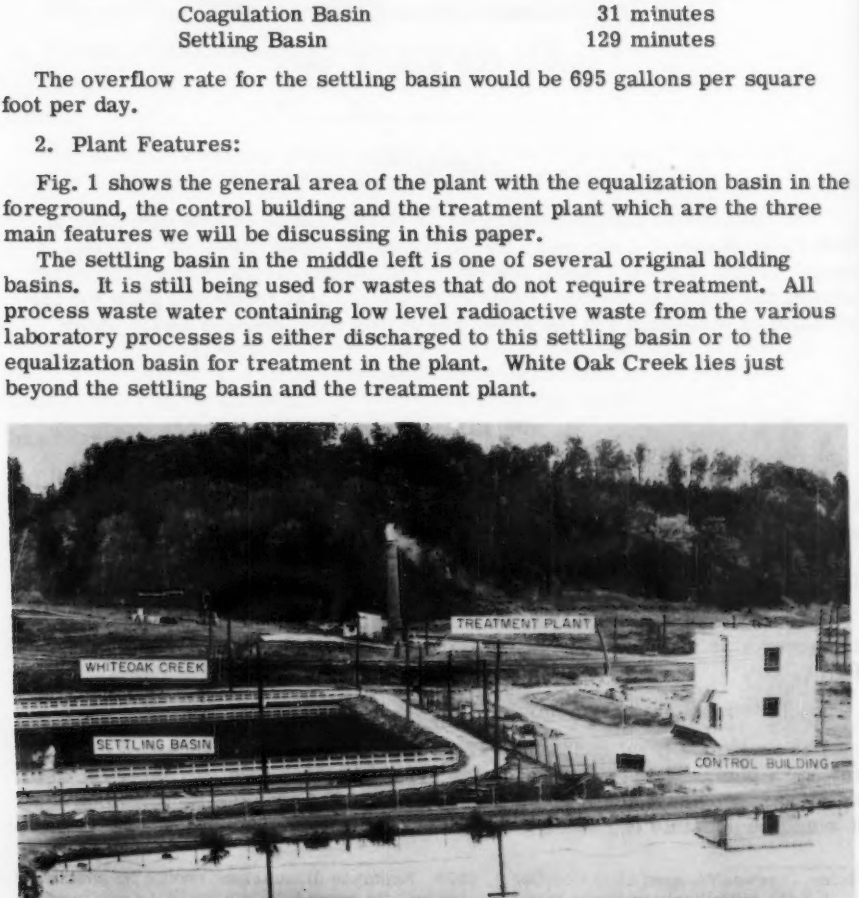

Fig. 1—General Plant Area

The treatment plant may or may not be operated continuously, depending upon the amount of wastes that are being produced that require treatment. If the amount of these wastes are insufficient to require continuous operation of the plant, the wastes are stored in the equalization basin until such time as it is deemed advisable to treat them. The equalization basin has a capacity of approximately 875,000 gallons. Since the pH fluctuates considerably, the equalization basin tends to give the wastes a chance to become more uniform in quality during the holding period. That is, the pH will tend to become less extreme in both directions.

Fig. 2 shows a cut-away of the control building and treatment line No. 1. The control building has three floors. The upper floor is for storage of bagged chemical and for charging the chemical feed hoppers which protrude above the chemical storage floor. There is also a "U" shaped trolley beam which carries an electrically operated hoist for handling pallets of bagged chemical. This hoist is also used for handling heavy equipment through hatchways in the ground floor as well as the chemical storage floor. The upper floor is reached by an outside stair from the loading dock. Trucks loaded with bagged chemical can be backed up to the loading dock, the pallets maneuvered into a position under the hook with a dolly and hoisted to the storage floor. The ground floor accommodates the chemical feed machines, the control panel, water heater, lavatory, sink and cabinets. The process waste water pumps are located in the basement of the control building as well as the process waste water piping and the steam and process water piping. The operators can reach the treatment plant by way of the chemical feed hoseway bridge or by a short walkway.

Fig. 3 was taken from the roof of the control building and shows very clearly the treatment plant and the equipment being used.

In the future another treatment line will be added along the right hand side of the structure as viewed from this point. This, then, will result in one treatment line on each side of the hoseway and pipe gallery. This will give the plant a symmetrical shape.

In the center foreground is the chemical feed hoseway bridge between the control building and the treatment plant. The hoseway is covered with chemically treated wooden planks which may be removed as needed to service the chemical hose. There is a live steam line, uninsulated, which will give enough heat to prevent the hose lines from freezing during the mild winters of this area. The rectangular structure at the end of the hoseway bridge is the sludge pump room and directly below the pump room is located the sludge sump which has a capacity of 10,500 gallons. The sludge sump, being so deep in the ground, is well isolated by the ground and concrete.

Referring again to Fig. 2, the first element in the treatment line is the flash mixer basin, followed by a three compartment coagulation basin which is 8' wide by 24' long and 9'-6" deep including 1'-4" of freeboard. The compartments are separated by wooden baffles and concrete fillets directly below the baffles since the baffles do not go all the way to the bottom.

These fillets are also provided along the side walls, thus giving the bottom of each compartment a sort of a hopper shape which, because of the rolling action created by the coagulators, are kept reasonably clean of sludge accumulations.

It is important to keep the basins as free as possible of sludge accumulations to prevent a build-up of radioactivity within them.

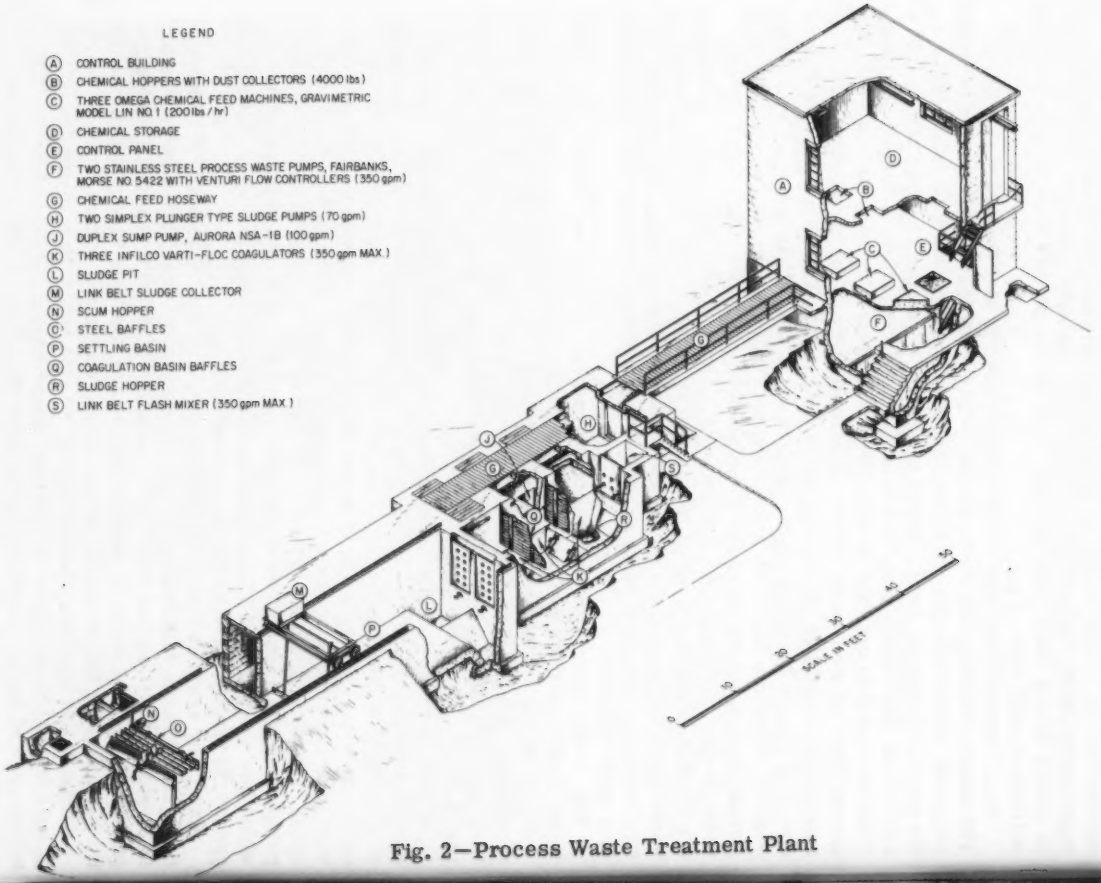
LEGEND
(A) CONTROL BUILDING
(B) CHEMICAL HOPPERS WITH DUST COLLECTORS (4000 lbs)
(C) THREE OMEGA CHEMICAL FEED MACHINES, GRAVIMETRIC MODEL LIN NO. 1 (200 lbs / hr)
(D) CHEMICAL STORAGE
(E) CONTROL PANEL
(F) TWO STAINLESS STEEL PROCESS WASTE PUMPS, FAIRBANKS, MORSE NO. 5422 WITH VENTURI FLOW CONTROLLERS (350 gpm)
(G) CHEMICAL FEED HOSEWAY
(H) TWO SIMPLEX PLUNGER TYPE SLUDGE PUMPS (70 gpm)
(J) DUPLEX SUMP PUMP, AURORA NSA-1B (100 gpm)
(K) THREE INFILCO VARTI-FLOC COAGULATORS (350 gpm MAX.)
(L) SLUDGE PIT
(M) LINK BELT SLUDGE COLLECTOR
(N) SCUM HOPPER
(O) STEEL BAFFLES
(P) SETTLING BASIN
(Q) COAGULATION BASIN BAFFLES
(R) SLUDGE HOPPER
(S) LINK BELT FLASH MIXER (350 gpm MAX.)
0 10 20 30 40 50
SCALE IN FEET

Fig. 2—Process Waste Treatment Plant

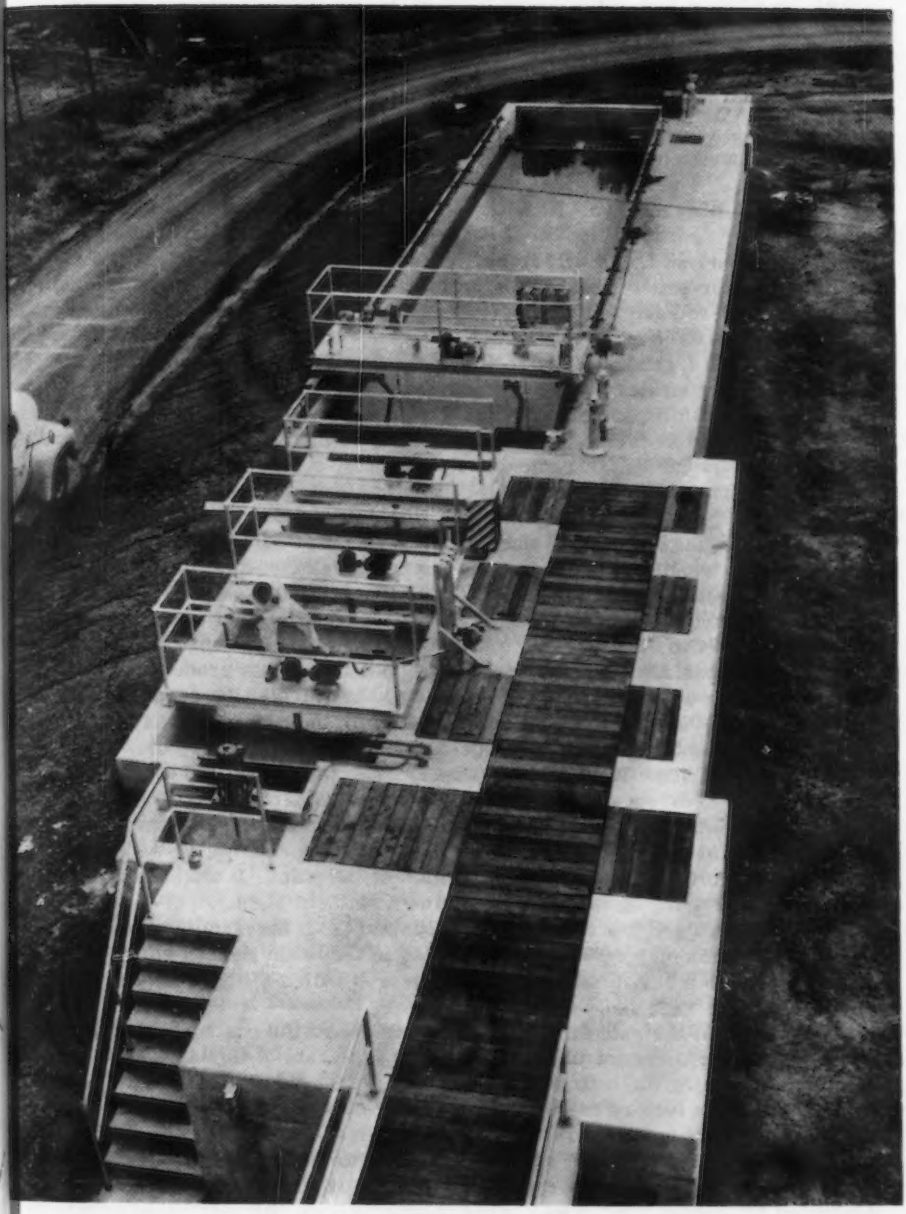

Fig. 3—Treatment Plant and Equipment

At the effluent end of the coagulation basin flat transite baffles are provided with circular holes in them, designed to smooth out and distribute the flow into the upper end of the settling basin. At the junction of the coagulation basin and the settling basin, two sludge pits are provided which receive the sludge that settles out in the settling basin. It is also possible to flush out the coagulation compartments through slots provided in the fillets just below the baffles and openings in the wall between the coagulation basin and the settling basin. The settling basin is 60' long by 12' wide and 9'-6" deep, including 1'-4" of freeboard. Near the effluent end of the settling basin a scum hopper is provided for removal of scum which may possibly accumulate. It is not expected that there will be very much scum accumulation. At the effluent end of the settling basin a baffle is provided which is followed immediately by launders equipped with serrated weirs. Discharge from the launders is directly into the overflow chamber.

The above is a general view of the plant. The following portion will give more detail. Laboratory wastes originate in many different places. It was necessary, therefore, to collect all of those wastes—bringing them to a common point, in so far as that could be done, so that they could be monitored to determine the amount of radioactivity they may be carrying. By use of pump stations and a common mixing box, it was possible to collect all of these wastes at one point except for one waste line. This waste line is pumped directly to the equalizing basin, since its activity is too high for the settling basin. As the waste leaves the mixing box it passes through a monitoring station which measures the activity. Should the activity rise above a predetermined amount, the valves in the diversion box just beyond would be actuated automatically as to close the valve to the settling basin and open the valve to the equalizing basin. When the activity dropped below this predetermined value the reverse action would occur, closing the valve to the equalizing basin and opening the valve to the settling basin. From the diversion box the flow is either to the settling basin or to the equalizing basin splitter box. This splitter box will make it possible at a later date, when a second equalization basin is built, to divert the flow to either or both equalizing basins.

The equalization basin, as discussed previously, is primarily used for the smoothing out of the fluctuations in the flow of the process waste water. Also, it makes possible the intermittent operation of the plant. It also has a tendency to provide a more uniform quality to the treatment plant.

The process waste water pumps take suction from the equalization basin through an 8-inch pipe. The pipe originates in the basin suction sump, which is equipped with a stainless steel frame covered with a stainless steel wire mesh.

The control of the rate through the plant is set on the control board on the operating floor of the control building. It sets the rate of flow through the plant by controlling the butterfly on the downstream side of the Venturi meter, both of which are located in the pump discharge line. The flow goes directly to the flash mixer basin, and from there through a 1" thick transite baffle which is provided with six 4" circular openings to smooth out the flow to the coagulation basin. From there it passes to the coagulation basin which is separated by wooden baffles into three compartments. As mentioned previously, part of this separation is accomplished by concrete fillets just below the baffles. These fillets are 2' high. The baffle between the first and second compartment is set 9" above the fillet and extends to the surface of the water,

while the baffle between compartment 2 and 3 is set 1'-6" above the fillet and extends to the surface of the water. It is possible to apply chemicals at the flash mixer basin and at each of the coagulation basins as desired.

There are two baffles in the wall between the coagulation basin and the settling basin of 1" flat transite. Each of these baffles has ten 4" diameter openings in it to insure uniform flow into the settling basin. The settling basin, as was noted previously, is 12' wide and provided with sludge pits adjacent to the coagulation end. There are two sludge pits, either of which can be blown off separately to the sludge sump or returned, in any desired proportion, to the pump suction header and recycled through the treatment plant. The effluent is removed by way of launders equipped with serrated weirs at the effluent end of the basin. The flow from this point is directly into the overflow chamber, and from there to the effluent chamber, or returned for recycling to the pumps in the control chamber. Any desired percentage of recycling can be made.

3. Special Problems:

Provision has been made for the addition of a second equalization basin to the west of the present one, which when added, will give more flexibility to the plant as well as add to the equalization capacity.

Provision also has been made for adding a second treatment line of 500,000 gallons per day capacity just to the right side of the pipe gallery by merely knocking out a concrete block wall and adding the necessary basins. The present sludge pumps and pipe gallery will serve both.

Because of the very low pH which may at times occur, the pipelines from the equalization basin to the flash mixer basin are rubber lined. The first 48 feet of the 8-inch suction line from the suction sump in the equalization basin is rubber covered. This protection was added because of the possible deep penetration of the corrosive liquid into the earth embankment through which the pipe passes. The pumps, Ventrui meters, and the valves are of stainless steel. The valves are of the plug type and have rubber faced plugs.

The floor under the process waste water pumps is covered with stainless steel sheets which also extend up the wall a short distance. This provision makes it possible to maintain the utmost cleanliness. Corroded and dirty equipment permits radioactive build-up. Any drippings or wastes occurring during overhaul of pumps or other equipment, are taken through drains in the floor to the sump pumps in the pipe gallery adjacent to the coagulation basins. These wastes are pumped directly to the coagulation basin and processed. Likewise, the floor in the sludge pump room is covered with stainless steel sheets, including the concrete foundations of the pumps, so that any wastes can be flushed to the sump pump and processed through the plant just as other wastes are handled.

Steam was piped to the control building and to the pipe gallery in the treatment plant for heating and for use in cleaning.

The basin equipment, including flash mixers, coagulators, and the sludge collector, were specified to receive at least two coats of polyethylene thermoplastic coating after fabrication. This was done so that the equipment could be removed from its foundation by a crane and hosed down easily, while still being suspended above the basin, to prevent too much contamination adhering to the surface.

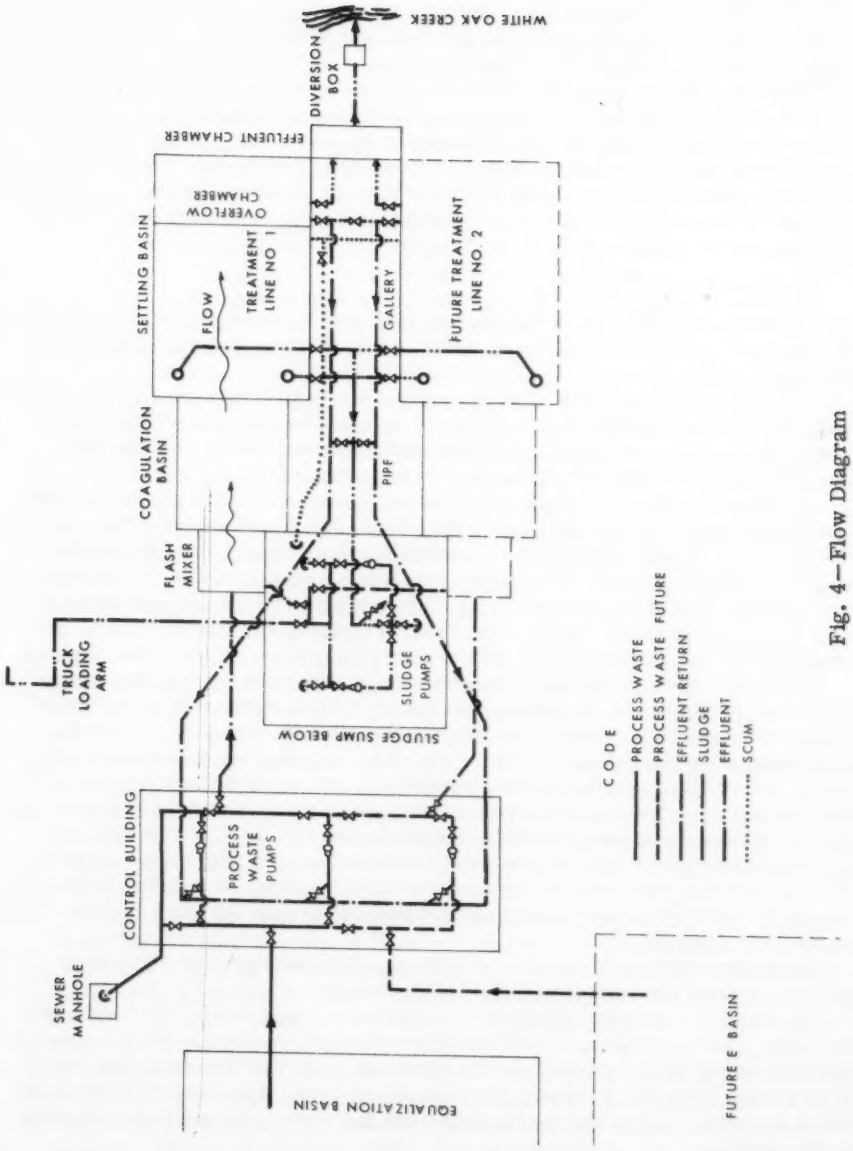

Fig. 4—Flow Diagram

Fig. 4—Flow Diagram

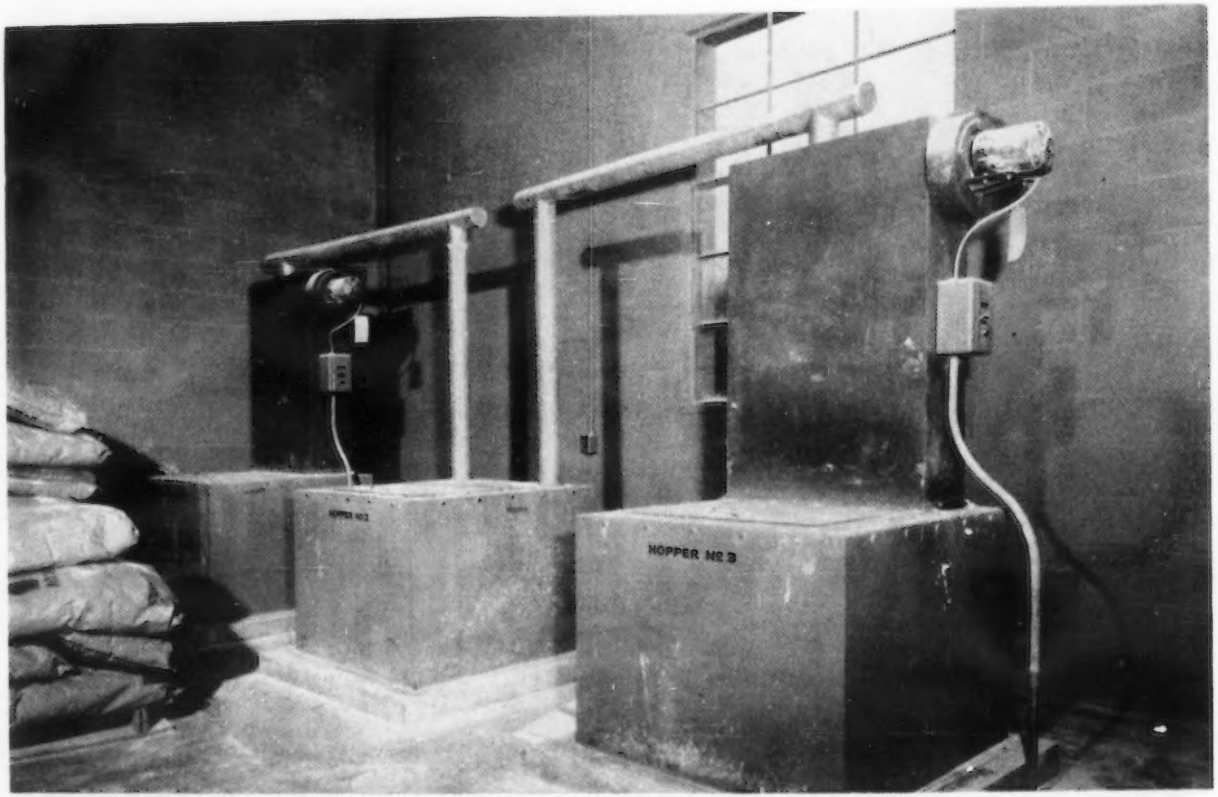

Fig. 5—Charging Hoppers - Chemical Storage Floor

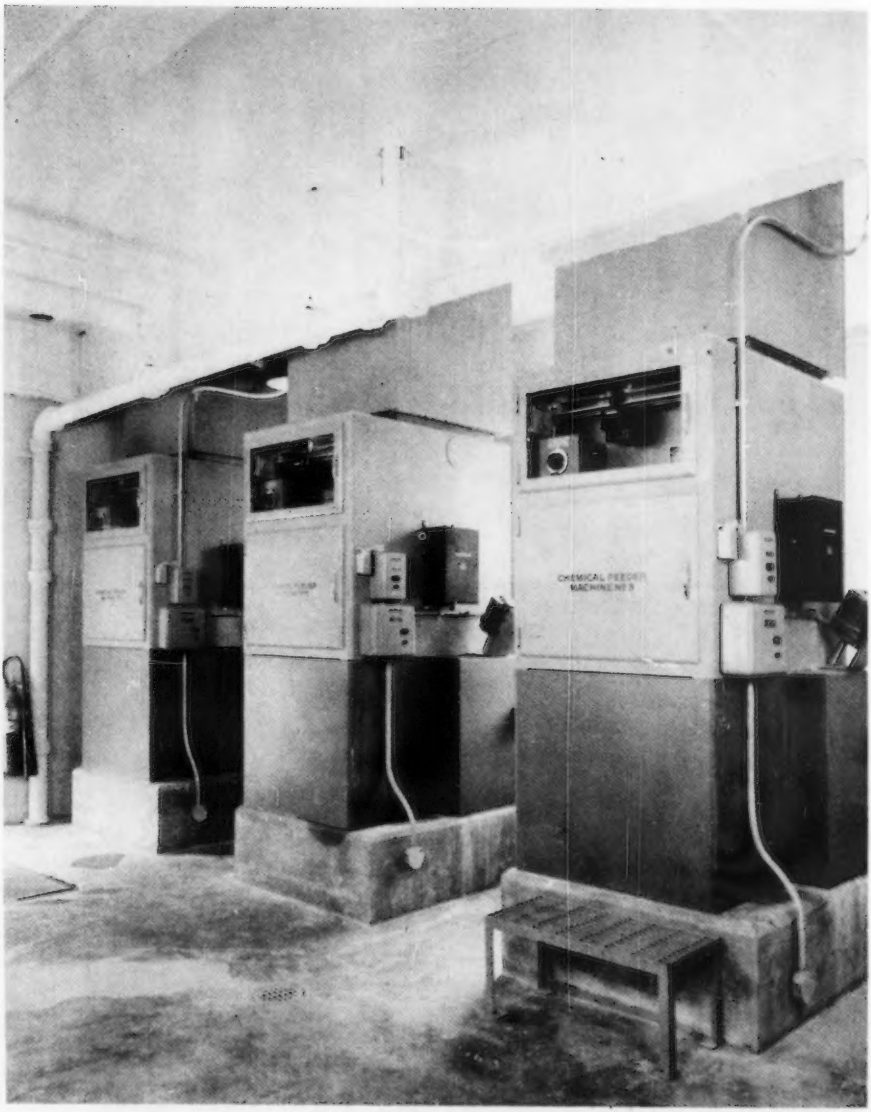

Fig. 6—Chemical Feeders - Operating Floor

The sludge sump, as mentioned above, has a capacity of 10,500 gallons—which is several times that of the tank truck—which is used to remove the sludge from the site to an isolated waste area. A sampling cock is provided on the sludge pump discharge line for taking samples to determine the moisture content in the sludge. The sludge in the sludge sump may be made uniform, after periods of rest, by pumping the sludge up and returning it directly to the sump again. The sludge is pumped from the sump through an underground pipeline to a tank truck loading arm, similar to that used for oil services. The truck used is an oil type tank truck with a capacity of approximately 3,500 gallons. The operator can stop and start the pumps from a point outside of the sludge pump room, thus making it unnecessary for him to be in the room through which the radioactive wastes are pumped.

It will be noted by referring to the flow diagram (Fig. 4) that the layout will provide for the following operations:

a. May pump from the equalization basin to the treatment plant.
b. Pump from the equalization basin to the sewer.
c. Return any desired percentage of effluent for recycling.
d. Draw sludge from the settling basin sludge pits to the sludge pump.
e. Pump sludge from the sludge sump to the sludge tank truck.
f. Pump sludge from the sludge sump to the flash mixer.
g. Pump sludge from the sump back to it.
h. Pump sludge from the settling basin sludge pits directly to the sludge tank truck or to the flash mixer.
i. Blow off sludge from either settling basin sludge pit to the sludge sump.
j. Draw sludge from the settling basin sludge pits through the effluent return line to the process waste water pumps for recycling.

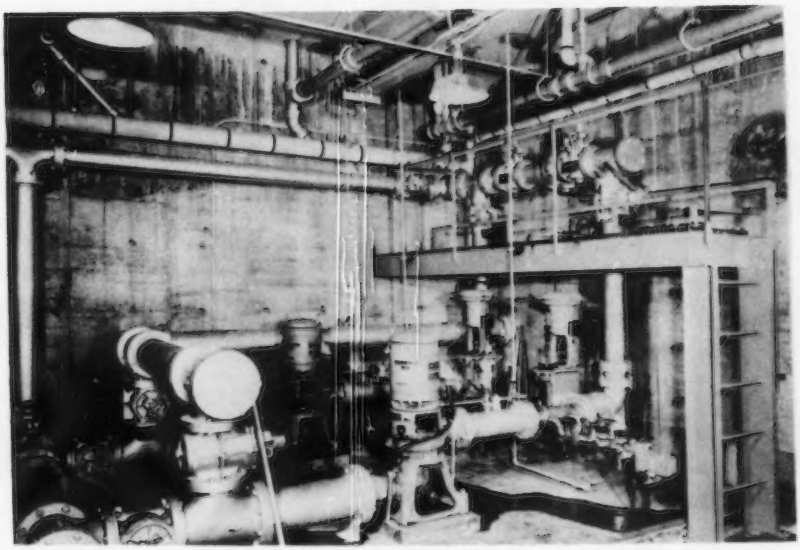

Fig. 7—Process Waste Pumps and Venturi - Basement Floor

k. Pump from the treatment basins back to the equalization basin.

After the second equalization basin is constructed, and treatment line No. 2 added, the following additional operations will be possible in addition to the above:

l. Operate treatment line No. 1 and treatment line No. 2 in series, or parallel.
m. Recycle both treatment lines in parallel to any desirable percentage.
n. Pump from one equalization basin to the other.

In summary it should be pointed out that there are three main features of the plant that make it different:

First—The provision for a wide range of flexibility in operation which gives it the character of a laboratory.

Second—The provisions for maintaining cleanliness by the use of:

a. Stainless steel floors.
b. Collecting drips and spills for reprocessing.
c. Hosing down of equipment as it is being removed for maintenance, and
d. By so constructing the basins as to prevent excessive accumulations of sludge.

Third—By providing for maintenance of basin equipment from above, thus avoiding the necessity of draining the water from the basins which is a very good shield against radiation.

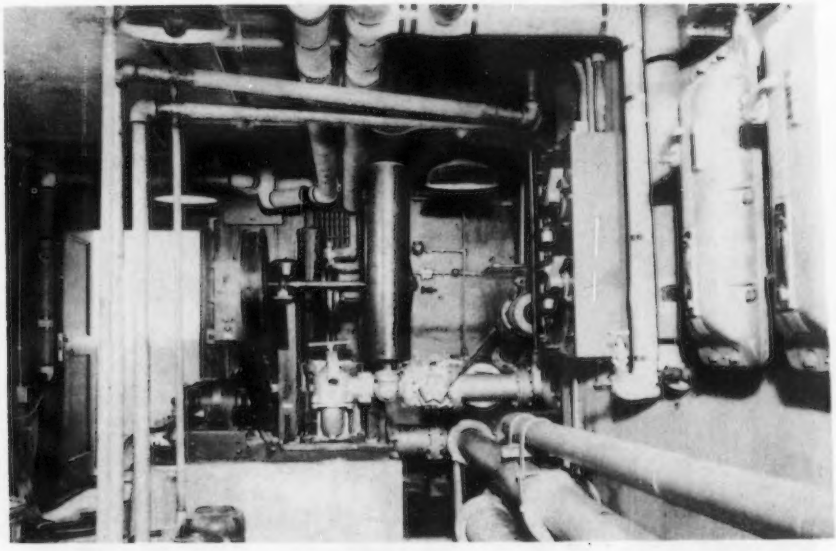

Fig. 8—Sludge Pumps - In Treatment Plant

ACKNOWLEDGEMENTS

The illustrations contained herein were obtained from the Oak Ridge National Laboratory and were reproduced with the permission of the Laboratory.

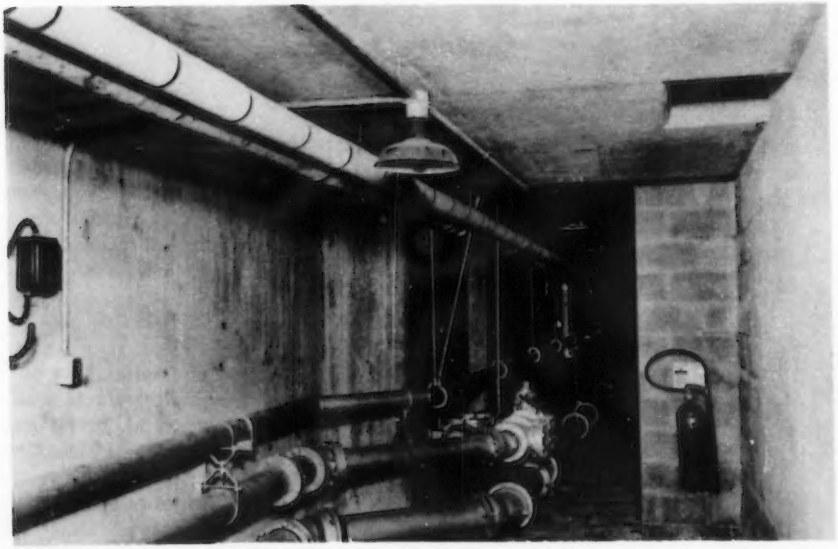

Fig. 9—Pipe Gallery - In Treatment Plant

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RADIOACTIVE CONTAMINANT REMOVAL FROM WASTE WATER: EVALUATION OF PERFORMANCE[a]

K. E. Cowser[1] and Roy J. Morton,[2] M. ASCE

ABSTRACT

The second of two papers relating to the design and operation of a plant at the Oak Ridge National Laboratory for the collection, treatment, and disposal of large volume (0.5 - 0.7 mvd), low level radioactive liquid waste. The paper covers the performance of the lime-soda softening process treatment plant and shows that it is an effective and economical method for the removal of strontium and other materials.

The safe and economical disposal of process waste water presents a problem at all atomic energy installations. These wastes are usually low in radioactivity but large in volume. However, the total quantity of radioactive constituents is often too great to be diluted sufficiently in the environment; uncontrolled release is not desirable. When treatment of the waste is required: (1) the process should concentrate the major portion of the radioactive contaminants to facilitate safe and permanent disposal; (2) the process should be sufficiently flexible for adaptation to changes in flow and chemical characteristics of the waste; (3) the process should provide a reserve capacity for more intensive treatment in case of accidental spills or emergency releases; and (4) the cost per unit volume of waste treated should be low.

Types of Radioactive Liquid Wastes

At Oak Ridge National Laboratory (ORNL) there are three liquid waste streams that contain radioactive materials. These are:

Note: Discussion open until October 1, 1959. Separate discussions should be submitted for the individual papers in this symposium. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 2033 is part of the copyrighted Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. SA 3, May, 1959.

a. Presented at the October 1958 ASCE Convention in New York, N. Y.

1. Oak Ridge National Lab., operated by Union Carbide Corp. for the U. S. Atomic Energy Commission, Oak Ridge, Tenn.
2. Oak Ridge National Lab., operated by Union Carbide Corp. for the U. S. Atomic Energy Commission, Oak Ridge, Tenn.

(1) Process wastes (contaminated waste water) in volumes of 200-300 million gallons per year which contain between 200 and 500 curies of radioactivity per year. A discussion of these wastes and their treatment is the main purpose of this paper.

(2) Intermediate-level wastes (referred to as chemical wastes at ORNL) which average 2 to 3 million gallons per year with beta activities of about 10^5 to 10^6 counts per minute per ml (c/m/ml).* These wastes are held in underground tanks for neutralization, followed by disposal to waste pits which utilize the sorptive capacity of an indigenous shale formation.[1,2]

(3) Metal wastes containing recoverable heavy metals and radioactivity of intermediate levels (as in 2 above). These are held in underground tanks for neutralization and metal recovery. The liquids containing the fission products are disposed of in the same way as the intermediate-level chemical wastes.

The Process Waste System

These three types of liquid waste are collected in separate systems. Radioactivity monitoring points are provided, and the different wastes are directed from their sources to the appropriate system for handling and disposal.

Process wastes come from equipment cooling water, floor drains, decontamination pad drains, storage canals, laboratory sinks, and miscellaneous low activity operations. A network of 6-inch to 30-inch diameter vitrified clay pipe is used to collect and convey the wastes by gravity flow through a central monitoring point to the settling basin or to the equalization basin. The system is divided into three main sections which, in turn, are subdivided by means of strategically located monitoring stations. These stations are concrete manholes in which a V-notch weir, float recorder, and a Sigma pump for the collection of samples are located. A flow diagram of the waste system is shown in Fig. 1.

The volumes and radioactivity levels of the process waste during the years 1950 to 1957 are summarized in Table I. The total volume varies from about 165 to 298 million gallons per year, or an average of 0.45 to 0.81 million gallons per day (mgd). The fourth column in Table I, headed "Retention Pond," refers to radioactivity contributed by the drainage from monitoring pads underneath the underground waste storage tanks. The total gross beta activity discharged from the process waste system and the retention pond to White Oak Creek varies from 172 to 498 curies per year.

The effluent from the settling basin is measured and composite samples are collected by a continuous proportional sampler at the weir box** near the point of discharge to the Creek. Radiochemical analyses of these samples for five years (1953-1957) are summarized in Table I. Most of the radioactivity in process waste is due to trivalent rare earths (including cerium), cesium, and strontium; lesser amounts are contributed by ruthenium, zirconium, iodine, niobium,barium, and cobalt.

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*All results are referred to second-shelf counting using an end-window Geiger counter.

**Weir box is equipped with: (1) Standard 90° V-notch weir; (2) Standard USGS installation of water level recorder; and (3) Trebler sampler supplied by Lakeside Engineering Corporation, Chicago, Illinois.

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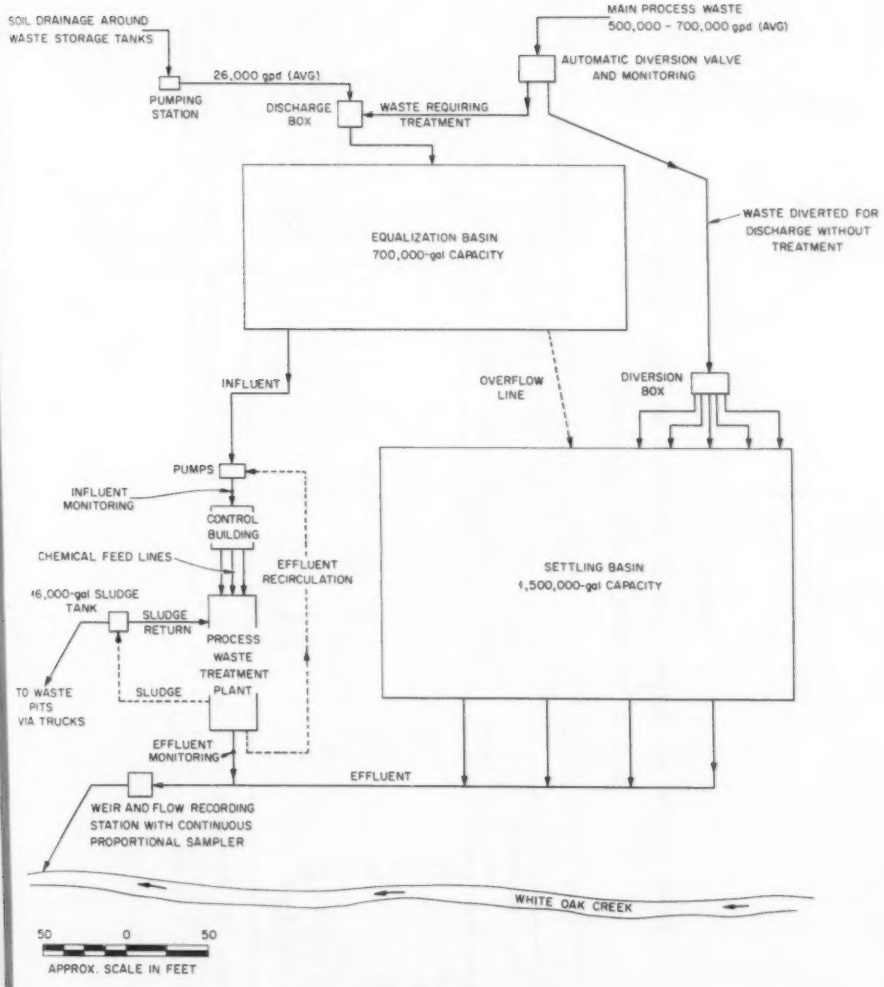


FIG. 1 Flow Diagram of Process Waste System.

The location and surface water drainage system of the Laboratory and its environs is shown in Fig. 2. The wastes discharged to White Oak Creek flow approximately three miles through the Creek channel, the basin of White Oak Lake, White Oak Dam, and the embayment above the mouth of the Creek. The average annual rate of flow of the Creek into the Clinch River, obtained from data at gaging stations on White Oak Creek and Melton Creek, is approximately 5 cubic feet per second (cfs). Occasionally, heavy floods cause rates of

TABLE I

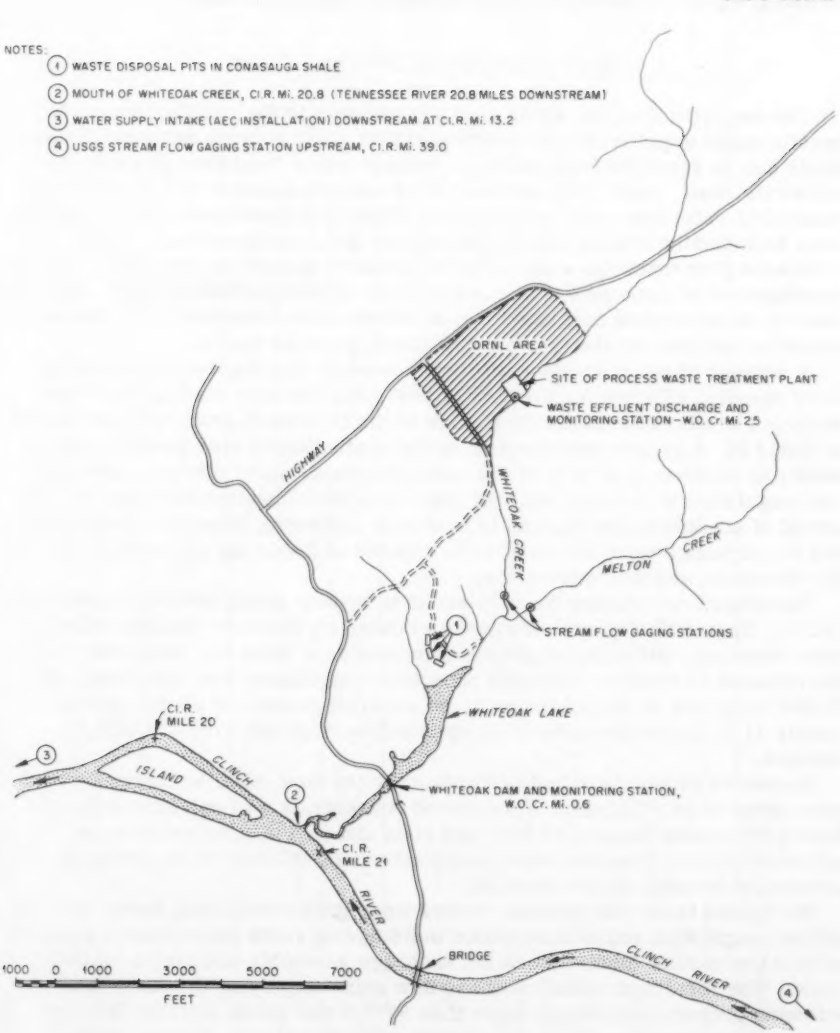
YEARLY VOLUMES AND RADIOACTIVITY OF DISCHARGES OF LIQUID WASTES

TO WHITE OAK CREEK AT ORNL, 1950-1957[a]

Year	Total Volume 10^6 gals	Gross Beta Activity Curies			Per Cent of Gross Beta Activity Identified with Specific Radionuclides								
		Settling Basin	Retention Pond	Total	TRE[b] (-Ce)	Ce	Ru	Zr	Cs	I	Sr	Nb	Ba	Co
1950	226.4	172	15	187										
1951	297.6	169	3	172										
1952	268.2	411	87	498										
1953	239.4	289	140	429	53.1	2.6	0.8	2.6	8.5	0.2	27.6	1.0	0.8	---
1954	164.3	237	17	254	34.6	19.1	0.5	1.0	20.3	0.5	23.3	0.4	0.3	---
1955	210.6	213	54	267	30.3	14.7	3.1	0.6	31.6	0.2	18.7	0.6	0.2	---
1956	260.7	253	20	273	24.4	12.3	2.0	0.5	42.1	0.1	15.1	1.0	0.2	2.2
1957	272.3	(combined)		189	25.8	4.4	1.0	10.2	36.5	0.0	18.0	0.7	0.0	1.8

a. Volume of settling basin effluent measured in weir box with liquid level float recorder. For determinations of radioactivity continuous proportional samples of the effluent are composited for daily gross beta measurements and monthly radiochemical separations and analysis.

b. Trivalent rare earths exclusive of cerium.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NOTES:
1 WASTE DISPOSAL PITS IN CONASAUGA SHALE
2 MOUTH OF WHITEOAK CREEK, CI.R. Mi. 20.8 (TENNESSEE RIVER 20.8 MILES DOWNSTREAM)
3 WATER SUPPLY INTAKE (AEC INSTALLATION) DOWNSTREAM AT CI.R. Mi. 13.2
4 USGS STREAM FLOW GAGING STATION UPSTREAM, CI.R. Mi. 39.0
ORNL AREA
SITE OF PROCESS WASTE TREATMENT PLANT
WASTE EFFLUENT DISCHARGE AND MONITORING STATION – W.O. Cr. Mi. 2.5
HIGHWAY
WHITEOAK CREEK
MELTON
CREEK
STREAM FLOW GAGING STATIONS
WHITEOAK LAKE
CI.R. MILE 20
ISLAND
CLINCH
WHITEOAK DAM AND MONITORING STATION, W.O. Cr. Mi. 0.6
CI.R. MILE 21
RIVER
BRIDGE
CLINCH RIVER
1000 0 1000 3000 5000 7000
FEET

FIG. 2 Location Sketch Map
ORNL Area Surface Drainage

SA 3

flow in excess of 1000 cfs for several hours. The Creek discharges into the Clinch River at Cl. R. Mi. 20.8.* The mean annual flow in the Clinch River is approximately 5000 cfs which provides a dilution factor of about 1000 for the water and wastes discharged from White Oak Creek. Conditions of disposal into the Clinch River have been described in greater detail elsewhere.(3) It is the policy to comply with the recommendations of the International Commission on Radiological Protection regarding radioactive contamination in drinking water for nonoccupational and large population use.(4)

Bases of Design of Treatment Plant

The experience of the water works profession in the purification of domestic water supplies has demonstrated that many nonradioactive contaminants can be removed from water by various water treatment procedures at moderate cost. Since 1948, studies of the decontamination of low-level contaminated water have been conducted at ORNL and elsewhere. These studies have included the evaluation of conventional and nonconventional water treatment processes for removal of radioactive materials from water and the development of methods for increasing their efficiency.(5,6,7,8,9,10) The results of these studies suggested that modified water treatment procedures would be suitable for the treatment of ORNL process waste.

A number of water treatment processes were investigated to determine their removal efficiencies for Sr^{90}, Cs^{137}, and the rare earths, from tap water. The characteristic efficiencies of six treatment processes are shown in Table II. A prime consideration in the evaluation of each process was its ability to remove up to 90% of the radiostrontium. Sand filtration and chemical coagulation with aluminum and iron salts were unsatisfactory for the removal of strontium and cesium. Lime-soda softening, phosphate coagulation, and ion exchange were all found to be capable of removing more than 90% of the strontium and the rare earths.

The laboratory studies were extended to include actual process wastes at ORNL. Up to 90% removal of gross radioactivity could be obtained with excess lime-soda softening or phosphate coagulation when clay was added for the removal of cesium. Although phosphate coagulation was promising, efficient removals of strontium required accurate control of pH (to approximately 11.5) and of the ratio of phosphate (Na_3PO_4) and lime ($Ca(OH)_2$) dosages.

Increased removals of radiostrontium by the lime-soda softening process were found to be related to: (1) reduced concentration of calcium in the effluent; (2) excess dosages of lime and soda ash (above stochiometric requirements); and (3) successive precipitations of calcium in the presence of previously formed calcite crystals.

Pilot plant tests with process wastes were performed using three types of upflow coagulation and sedimentation units having rated capacities of 6 and 35 gallons per minute (gpm) and an ion exchange assembly utilizing a cationic resin. The results showed that the upflow units employing the lime-soda softening process removed greater than 50% of the gross activity, but that there was too much variation in removal efficiency due to changes in the chemical composition of the waste stream. Also upflow units were not well

*Cl. R. Mi. = Clinch River Mile - distance in miles numbered upstream from mouth of River.

TABLE II

REMOVAL OF RADIONUCLIDES FROM WATER BY CONVENTIONAL WATER TREATMENT PROCESSES

Radioisotope	Process Waste Stream Composition (per cent of gross beta 1954-1956)	Per Cent Removal by Treatment Process					
		Chemical Coagulation(1)	Chemical Coagulation Plus 100 ppm Clay	Sand Filtration	Lime-Soda Softening (150 ppm excess)	Phosphate Coagulation (240 ppm dose)	Ion Exchange
Sr	19.6	3	0-51	4	97.3	97.8	99.1-99.97
Ce	15.2	91	85-96	---	----	99.9	----
Trivalent Rare Earths (including Y)	30.4	91	----	87	90.0	----	75.0-98.7
Cs	29.9	0.5	35-65	50	Not Effective	----	99.8
Ru	1.9	77	----	---	----	----	----
	97.0						

(1) Coagulant includes alum, ferrous sulfate or ferric chloride, lime, soda-ash or sodium hydroxide, and sodium silicate.

adapted for repeated precipitation. The use of ion exchange was discouraging because of cost, the apparent need for pretreatment, the relatively short runs before regeneration was required, the variable chemical composition of the waste, and the operational difficulties experienced at the Laboratory with other ion exchange units.

The over-all results of the laboratory and pilot plant studies indicated that the process waste treatment plant should be a horizontal-flow, lime-soda water softening process with provisions for alternative use of phosphate coagulation for strontium removal and the addition of clay to increase the removal of cesium. To reduce the concentration of radioactivity from accidental or emergency releases, recirculation of the effluent for repeated treatment would be required.

The criteria of design and the major features of the treatment plant are reported in Part I, "Engineering Design Features," by M. C. Culbreath, Principal Engineer, Burns and McDonnell Engineering Company.

Operational Experience

The process waste treatment plant was completed in August 1957. With the new treatment plant available, process wastes can be held and treated as intensively as necessary, provided the level of activity is within the capability of the plant to achieve the required decontamination.

A new treatment plant usually requires a break-in period in which to reach optimum operation. During this period the operating personnel are trained, the mechanical components of the plant are adjusted; the limitations of the process are established; the proper combinations of chemical dosages are determined; and controls are established. This treatment plant is now in the break-in period and will remain so until these problems have been resolved. This paper describes the operating experience and removal efficiencies obtained during the first eleven months of operation.

Wastes requiring treatment are collected in the equalization basin of 700,000-gallon operating capacity (see Fig. 1). This basin serves to minimize fluctuations in composition of the plant influent and to supply waste for treatment. The wastes are by-passed automatically at the central monitoring station when the level of radioactivity is so low that treatment is not required. The by-passed wastes flow through the settling basin before discharge to the Creek. The effluent from the treatment plant joins the effluent from the settling basin and the combined discharge is monitored near the point of release to White Oak Creek.

From September 1957 through January 1958 the plant was operated 24 hours a day and 5 days a week. A 7-day operating week was initiated February 1958. Wastes were generally by-passed to the settling basin during the late evening and early morning hours when the major processes which produce radioactive wastes were not in operation. The automatic diversion system was placed into operation May 12, 1958. Since then, all wastes generated from 8:00 a.m. to 8:00 p.m. have been collected in the equalization basin; from 8:00 p.m. to 8:00 a.m., wastes are selectively by-passed, according to their level of radioactivity, by the automatic diversion equipment.

The components of the continuous water monitor and appurtenant diversion equipment have been described by Gillespie.(11) As shown in Fig. 3, the detector consists of five halogen-filled Geiger-Muller (GM) tubes enclosed in

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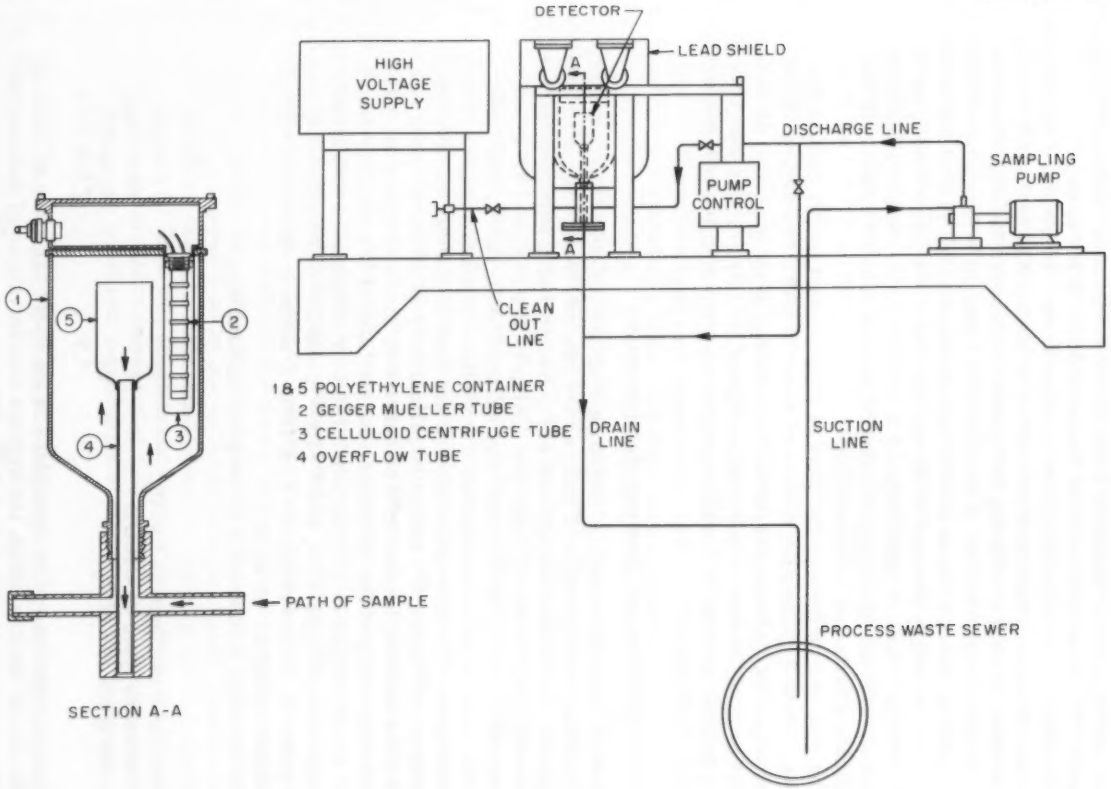

FIG. 3 Process Waste Water Monitor Assembly

celluloid centrifuge tubes and suspended within a one-gallon polyethylene container. A sample at a rate of one gallon per minute is pumped through the polyethylene container and back to the waste stream. Radioactivity detected by the GM tubes in the sample is continuously recorded, and a switch arrangement on the recorder actuates a motor-operated diversion valve. The sensitivity of the monitor to Sr^{90} - Y^{90} in equilibrium is 6.8×10^{-6} microcuries per milliliter. Based on MPC values for drinking water, Sr^{90} with its daughter Y^{90} is the most critical fission product in the waste.

The plant cannot treat all of the process waste. To optimize the removal of fission products from the total volume of waste, it is necessary to treat that portion of the waste having the greatest concentration of radioactivity. The minimum concentration of radioactivity required before waste is diverted to the settling basin must be determined by experience. A trial and error method is necessary because of the variable rate of waste release, the fluctuating concentrations of radioisotopes in the waste, the gross radioactivity determinations made by the water monitor, and the limited capacity of the equalization basin and treatment plant.

The rate of flow through the plant is kept constant at 300 gallons per minute. About 6 gallons per minute of water is added to this flow by each chemical feeder. During the first five months of plant operation 43 million gallons of process waste amounting to 34% of the total volume was treated. In the next six months 76.6 million gallons of waste was treated, accounting for 67% of the total.

Waste Composition and Chemical Requirements

Routine chemical analyses, including tests for pH, alkalinity, calcium, and total hardness, are performed daily on the raw and treated waste. Continuous samples of the influent and effluent are collected and composited for weekly and monthly radiochemical analyses. Samples are analyzed for gross beta activity, Sr^{89}, Sr^{90}, Cs^{137}, total rare earths (TRE), Ru^{106}, and Co^{60}. Specific radionuclides are separated from the composite samples by chemical techniques.(12) Absorption studies are used to distinguish between the amounts of Sr^{89} and Sr^{90}, and an empirical correction curve is used to adjust for the counting loss of Sr^{90} by carrier solids on the planchet. The observed count rates of the separated radionuclides of cesium, ruthenium, and cobalt are converted to disintegration rates by comparison with standardized solutions of Cs^{137} -Ba^{137m}, Ru^{106} -Rh^{106}, and Co^{60}. An efficiency factor of 10 is assumed in converting the TRE from c/m/ml to disintegrations per minute per milliliter (d/m/ml).

The chemical composition of the plant influent was as follows:

	Average	Range
Calcium hardness (ppm as $CaCO_3$)	86	33 to 135
Total hardness (ppm as $CaCO_3$)	127	59 to 180
Alkalinity (ppm as $CaCO_3$)	94	40 to 326
pH	7.3	2.5 to 11.5

The concentrations of radionuclides in the waste are given in Table III. For the eleven months listed, the average concentrations of radionuclides in the influent were: 18 d/m/ml of Sr^{89}, 270 d/m/ml of Sr^{90}, 260 d/m/ml of TRE, 220 d/m/ml of Cs^{137}, 18 d/m/ml of Co^{60}, and 33 d/m/ml of Ru^{106}.

The compositing of monthly samples has an averaging effect on the concentration of activity as seen by the gross beta activity in weekly samples which has ranged from 21 c/m/ml to 260 c/m/ml.

During this period only lime and soda ash have been used continuously in the treatment process. The studies of McCauley[8] indicated the need for reducing calcium to low levels for efficient strontium removal, while those of Hoyt[10] suggested that an excess dosage of lime and soda ash was instrumental in removing greater quantities of strontium. Therefore, various combinations of lime and soda ash were tried. Theoretically, the amount of material added is sufficient to satisfy the stoichiometric requirements of the raw waste and also provide a pre-established excess of lime and soda ash in the system. The amount of lime is based on the consumption of lime by carbon dioxide, carbonate hardness, magnesium hardness, and the excess dosages required. Sufficient soda ash is added to combine with the non-carbonate hardness and excess lime, and to maintain an excess of carbonates in the waste. The calculations are based on the equations describing the reactions in the lime-soda process given by Black.[13]

Efficiency of Plant Operation

From the analyses of composite samples of the plant influent and effluent (Table III), the efficiency of the treatment process is determined. The percentage removal of the important radionuclides for monthly periods is given in Table IV. Strontium removals ranged from 66% to 87% and have been as high as 94% for individual weeks. The total rare earths were removed as efficiently as the strontium. The reduction of gross beta activity ranged from 53% to 87% and was dependent on the concentration of radionuclides in the waste and the type and amount of chemicals used. The increased reduction of gross activity during November 1957 was partially attributable to the efficient removal of Pa^{233} from the waste. This was indicated by the fact that the sample of influent for November contained 240 d/m/ml of Pa^{233}, while it was not detected in the sample of the plant effluent.

To test the reliability of the analytical techniques employed for strontium and total rare earth determinations, the differences in percentage removals calculated from weekly and monthly composite samples (see Table IV) were treated statistically. The differences in percentage removals as calculated were not different from zero, even at the 80% level of significance.

Since clay has not been added on a continuous basis cesium removals were low as was anticipated. During the week of December 9, 1957, 30 ppm of Conasauga shale* were added to the waste, and cesium removals increased from about 16% to 55%. The affinity of the shale for cesium was determined by Jacobs and Tamura[14] to be due to the illitic type of clay mineral that comprises a large fraction of the shale. Voids created by the nonexpanding lattice structure of illite will accommodate ions of the size of cesium ions. Guided by this knowledge, a commercial clay product of high illite composition was recently procured, and addition of this clay to the treatment process begun.**

*Conasauga shale dried and ground—containing 40% illite, 25% montmorillonite, and 35% silica.

**Grundite: produced by the Illinois Clay Products Company, Joliet, Illinois—containing 65 to 75% illite, 10 to 20% kaolinite, and 5 to 15% quartz.

TABLE III

CONCENTRATION OF RADIONUCLIDES IN TREATMENT PLANT INFLUENT AND EFFLUENT[a]
(Monthly Composite Samples)

Date	Influent							Effluent						
	Gross Beta Activity	Sr^{89}	Sr^{90}	TRE	Cs^{137}	Co^{60}	Ru^{106}	Gross Beta Activity	Sr^{89}	Sr^{90}	TRE	Cs^{137}	Co^{60}	Ru^{106}
Sept. 1957	110	41	280	220	240	30	80	36	5.2	34	23	210	13	74
Oct. 1957	64	13	200	200	180	23	33	21	3.7	55	48	150	18	34
Nov. 1957	160	16	210	180	150	13	70	20	3.2	43	36	120	3.8	12
Dec. 1957	70	12	190	210	130	17	33	14	1.9	32	27	80	3.0	11
Jan. 1958	77	16	310	250	180	17	40	36	4.1	80	66	---	3.9	14
Feb. 1958	46	16	140	170	150	14	21	20	5.0	45	57	90	6.2	12
Mar. 1958	77	17	270	300	170	12	23	21	2.6	42	37	110	3.6	8.0
Apr. 1958	79	13	260	280	170	15	15	24	2.1	42	40	100	3.9	4.0
May 1958	94	15	340	340	320	25	24	39	3.4	73	67	320	9.6	7.3
June 1958	89	14	260	260	300	17	17	39	2.3	43	38	320	5.6	13
July 1958	140	21	520	400	480	20	10	63	3.2	81	55	500	5.8	7.1

(a) Gross beta activity in units of c/m/ml referred to second-shelf counting using an end-window Geiger counter. Sr^{89}, Sr^{90}, TRE, Cs^{137}, Co^{60}, and Ru^{106} in units of d/m/ml.

TABLE IV

REMOVAL OF RADIONUCLIDES BY TREATMENT

	Percentage Removals								Curies Removed				
	Monthly Composite Samples						Weekly Composite Samples		Monthly Composite Samples				
Date	Gross Beta Activity	Sr^{89+90}	TRE	Cs^{137}	Co^{60}	Ru^{106}	Sr^{89+90}	TRE	Sr^{89+90}	TRE	Cs^{137}	Co^{60}	Ru^{106}
Sept. 1957	67	87	89	9.5	51	7.6	88	89	3.7	2.6	0.62	0.02	0.19
Oct. 1957	68	73	77	19	23	0	73	73	2.6	2.7	0.84	0.12	0
Nov. 1957	87	80	80	21	72	83	75	82	2.4	1.9	0.23	0.12	0.74
Dec. 1957	79	84	87	40	83	67	83	85	2.4	2.6	0.74	0.21	0.31
Jan. 1958	53	74	74	----	76	65	71	75	3.6	2.7	----	0.19	0.38
Feb. 1958	57	66	67	42	56	42	65	65	2.3	2.4	1.4	0.17	0.18
Mar. 1958	73	85	88	32	69	66	84	85	4.7	5.1	1.1	0.16	0.30
Apr. 1958	70	84	86	40	74	74	84	87	5.3	5.5	1.6	0.25	0.26
May 1958	59	78	80	0	61	69	86	86	6.0	5.9	0	0.34	0.36
June 1958	57	84	86	0	67	24	90	89	5.2	5.2	0	0.25	0.09
July 1958	55	85	86	0	70	30	78	81	10	7.6	0	0.30	0.06
							Total -------		48	44	6.5	2.1	2.9

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Weekly composite samples were analyzed for calcium hardness and total hardness, as well as for strontium and the total rare earths. The percentage removals of strontium and the total rare earths were graphed as a function of the residual calcium remaining in the plant effluent are shown in Fig. 4 and Fig. 5. As calcium residuals increase, the percentage removal of strontium decreases, and the apparent relationship is expressed as a coefficient of correlation of -0.74; the 95% confidence limits are -0.57 and -0.86. Similarly, the coefficient of correlation between calcium residuals and the total rare earths is -0.66 with 95% confidence limits of -0.45 and -0.79. The real meaning of these relationships can be determined only after the mechanism of strontium and total rare earth removals has been established. Although the amount of precipitated magnesium is about 7% of the precipitated calcium, the carrying capacity of magnesium hydroxide for strontium and the total rare earths must be determined. There is no apparent relationship between the amount of calcium carbonate that is precipitated and the removal of strontium.

By using an excess of soda ash above that required by the noncarbonate hardness and excess lime, increased removals of calcium were obtained. This would be expected from the common-ion effect, since calcium, in the presence of excess carbonate, must be correspondingly reduced in order to maintain the ion product equal to the solubility constant of calcium carbonate. At the present time excess lime is not used but 200 ppm of excess soda ash are being used.

A relationship exists between the per cent removal of strontium and the total rare earths and is expressed as a coefficient of correlation of 0.89. The 95% confidence limits for the correlation coefficient are 0.81 and 0.94. With percentage removals of total rare earths as ordinates and percentage removals of strontium as abscissa, the relationship is given by the equation $Y = 13.3 + 0.856\ X$.

The curies of individual radionuclides removed each month are shown in Table IV. A total of 48 curies of strontium and 44 curies of total rare earths were removed. Since February 1958, when continuous operation of the plant was started, about 67% of the process waste was treated and 67% of the strontium in the total waste stream was removed. Although this would imply 100% removal of strontium, it actually demonstrates that waste collected by the equalization basin had a higher concentration of strontium than waste bypassed to the settling basin. The radioactivity removed is contained in the calcium carbonate and magnesium hydroxide sludge that is produced in the treatment process. For the first eleven months of operation 387,000 gallons of sludge containing an average of 52% solids by volume were transferred by tank truck to the waste disposal pit system.(2)

Difficulties with Plant Operation

Low temperatures influence the removal of calcium from the waste. During cold weather the amount of calcium remaining in the plant effluent increases. With additional time of contact, up to fifty hours, it has been found that the calcium in solution or in fine colloidal suspension is reduced by 50%. Since the settling tank of the plant was designed to provide a contact time of 2.15 hours, some means of increasing the rate of reaction that results in the precipitation and settling of calcium carbonate is necessary. Recycling previously settled sludge from the settling basin to the flash mixer in experimental amounts of 200 ppm was found to be effective in aiding the reduction of calcium residuals.

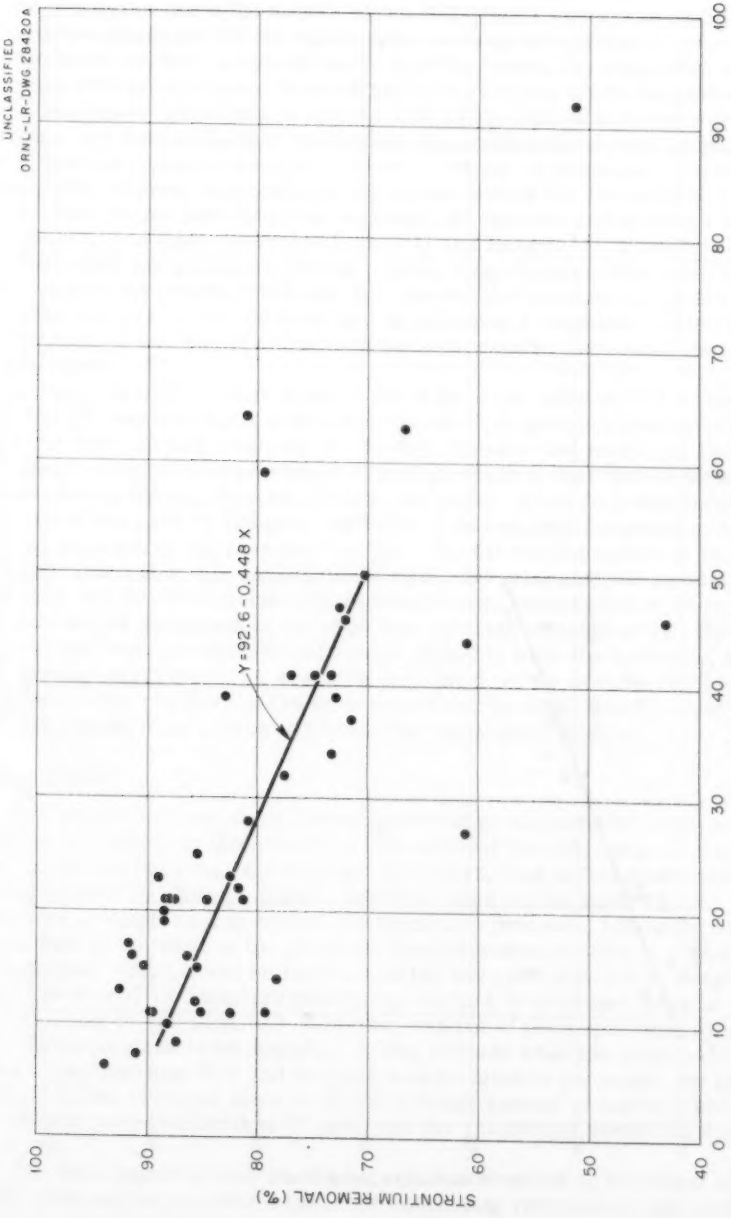

Fig. 4 Relation of Ca^{++} Residual to Strontium Removal.

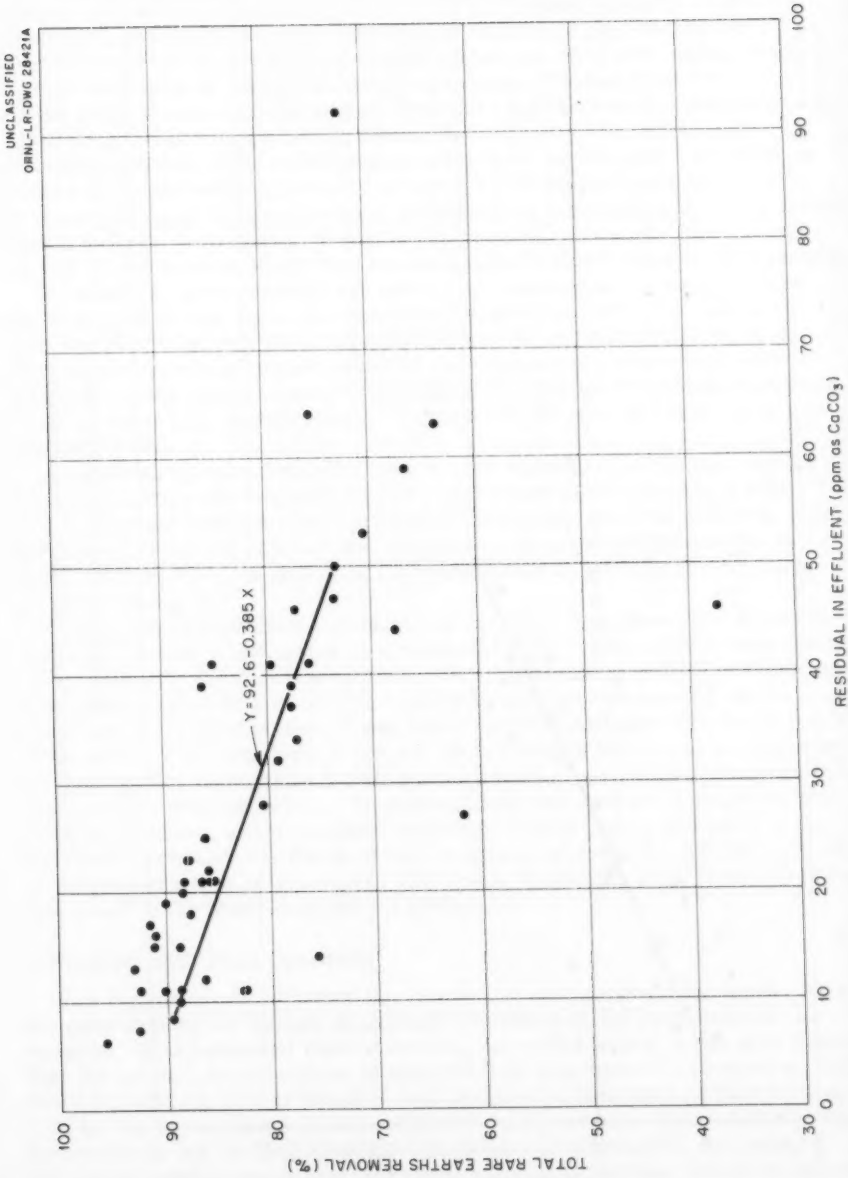

FIG. 5 Relation of Co^{++} Residual to Total Rare Earths Removal.

Complexing agents, such as versene, are used for decontamination purposes. Versene is known to chelate calcium, magnesium, and strontium, in preferential order, and most efficiently in alkaline solution.(15) In one instance the presence of versene was believed responsible for inefficient removal of calcium from the waste. About 550 ppm of sludge was recycled through the plant, but did not improve the removal of calcium.

For short periods during the early morning hours, the suspended solids in the plant effluent increase. In some instances the amount of suspended material leaving the plant was as high as 10% of the total solids that were formed. The percentages of magnesium hydroxide and calcium carbonate of the suspended material were not defined. The use of coagulants to aid in the flocculation of these suspended solids is one method for eliminating this difficulty. The proper selection of a coagulant aid depends on knowledge of the charge of the colloid. Although Clarke(16) and Larson(17) agree that magnesium hydroxide has a positive charge, Clarke reports that calcium carbonate bears a positive charge, while Larson reports that calcium carbonate bears a negative charge. Thus, the first step in selecting a coagulant aid is the determination of the type of colloid and its charge under the conditions in which it is formed.

During a period of three days the pH of the plant influent was less than 3.0. The low pH was the result of dropping the level in the equalization basin to only one foot, thereby reducing the volume of waste that would act as a buffer for small releases of acid. Now a minimum depth of four feet of waste is maintained in the equalization basin at all times. Lime feed was inadvertently increased from 200 to 400 ppm, while the soda ash feed remained at 200 ppm for the first day of the period of low pH. The pH was increased to 11.5, but residual calcium was in excess of 150 ppm. By reversing the amount of lime and soda ash introduced, calcium residuals were reduced below 35 ppm.

Mechanical equipment at the plant has operated satisfactorily. By experience it has been determined that sludge draw-off from the collecting sump in the settling basin should be operated each morning for about three-fourths of a minute. The impeller of the flash mixer and the flash mixing basin are steam-cleaned once a week to prevent the build-up of sludge.

RESIDUAL IN EFFLUENT (ppm as $CaCO_3$)

FIG. 5 Relation of Ca^{++} Residual to Total Rare Earths Removal

Plant Control

The results of these first eleven months of plant operation suggest that the amount of calcium in the effluent is indicative of the efficiency of removal of strontium and the total rare earths. Therefore, high softening efficiency appears desirable. Since a calcium determination can be made rapidly, it may serve as a simple test to control the treatment process. Laboratory studies show that an increase in the pH of the treated wastes results in a decrease of the residual calcium and an increase in the per cent removal of strontium. A pH in excess of 10.5 appears desirable, and this is in accord with the findings of McCauley(8) and Hoyt.(10) However, control of plant operation by pH determinations alone is inadequate. During periods when the temperature of the waste was less than 9° C and versene was detected in the waste, the pH of the plant effluent averaged about 11.0; the average amount of calcium remaining in solution was greater than 57 ppm, and the removal of strontium was decreased.

The high degree of correlation between the removal of strontium and the total rare earths provides a basis for estimating removals of the rare earths

with fewer analyses. The cause and effect relationship points to the removal of strontium and the rare earths by coprecipitation. However, the exact mechanism of removal remains to be determined. Nevertheless, the routine analysis of weekly composite samples for the rare earths has been discontinued; analysis for this group of isotopes will be continued in the monthly composite samples.

The plant was designed to allow the addition of various amounts and combinations of lime, soda ash, clay, returned sludge, and calcium chloride. It is desirable to determine the optimum dosage for each of these materials which will remove the greatest amount of radioactive strontium and cesium. Since a trial and error attempt to vary five factors on an operating scale is difficult to control, further laboratory studies are necessary.

To determine the importance of each of these five variables, separately and in combination, and the characteristics of their response surfaces, Gardiner[18] constructed a statistical experiment referred to as a Second Order Rotatable Design.[19,20] Fewer experiments are required to attain the desired information. The design provides for testing the effect of each variable independently, in combination with each of the other variables, and to detect curvature in the response surface of each variable.

While the study has not been completed, preliminary results are available. The first series of jar tests using typical process waste were performed in two groups; the first group contained 23 beakers and the second group 10 beackers. The range of concentration of each variable was based on experience in plant operation and prior laboratory studies. The range of concentrations used were as follows:

lime	stoichiometric requirement to 210 ppm excess
soda ash	stoichiometric requirement to 300 ppm excess
sludge (calcium carbonate)	0 to 2000 ppm
calcium chloride	0 to 10 ppm in each of three additions
clay (Conasauga shale)	0 to 200 ppm

The results of these tests showed that the removal of strontium was influenced primarily by the addition of soda ash and the removal of cesium was influenced by the addition of clay. The effects of soda ash on strontium removal and clay on cesium removal are directly proportional and significant at the 5% level. Guided by the results of the first 33 tests, 10 additional tests were performed. Lime dosage was varied from the stoichiometric requirement to one-third of the requirement; soda ash was varied from the stoichiometric requirement to 375 ppm excess dosage; and clay type (Conasauga shale and Grundite), dosage, and particle size were also varied. Soda ash and lime (less than stoichiometric dosage) affected strontium removals, while clay type, dose, and size affected cesium removal. All of the effects were significant at the 5% level. As the lime dosage was increased to the stoichiometric requirement strontium removals were increased. Soda ash dosage greater than stoichiometric increased strontium removals. Grundite was 11% more effective on the average than Conasauga shale in the removal of cesium. Also, the removal of cesium increased as dose increased and particle size decreased. Additional tests will be run employing combinations of lime, soda ash, and Grundite (particle size and dosage) that should lead most rapidly to optimum removals of strontium and cesium.

The laboratory study described above will furnish information to optimize the removal of strontium for the readily observable and controllable variables,

lime and soda ash. However, the basic mechanism responsible for the removal of strontium in ORNL process waste must be determined before strontium removals can be maximized. The use of illitic type clay mineral for the removal of cesium exemplifies the improvement that can be made in a treatment process when the mechanism of removal is understood.

Information obtained from operation of the treatment plant and laboratory studies indicate that the removal of strontium by the precipitation of calcium carbonate is due to coprecipitation. Hahn[21] categorized four types of coprecipitation: (1) the formation of isomorphous mixed crystals where foreign ions are incorporated isomorphously in the crystal lattice; (2) surface adsorption by the precipitate after it has already been formed; (3) internal adsorption of impurities during formation of the crystals; and (4) the formation of anomalous mixed crystals.

An understanding of the coprecipitation phenomenon responsible for the removal of strontium may allow adjustment of plant operation to maximize removal of the radioisotope. For example, as pointed out by Bonner and Kahn,[22] if coprecipitation is by mixed crystal formation, rapid precipitation from a supersaturated solution followed by the immediate removal of the precipitate from its mother liquor is the most efficient process. If surface adsorption is the primary mechanism of removal, allowing the precipitate to remain in contact with the solution will decrease the amount of strontium removed. Therefore, prompt removal of sludge from the settling basin is desirable. However, if internal adsorption is the responsible mechanism for removal, the fraction of tracer removed may increase as the precipitate remains in contact with the solution. Prompt removal of sludge may, therefore, be detrimental to maximum plant efficiency. Fundamental studies of the ORNL system are necessary before the mechanism of strontium removal can be determined.

Cost of Treatment

The unit cost for treatment of the process waste is difficult to determine, since it is influenced by a number of factors, some of which are variable or indefinite. With only limited experience in operation of this plant, absolute values could not be placed on certain factors, and these were not included in the calculations. It should be recognized that the costs summarized here are incomplete. They may be substantially greater when based on a longer period of operation and a more complete analysis of all operational requirements.

The total cost of chemicals used in treatment of the process waste for the first forty-seven weeks of operation is based on unit costs of lime and soda ash at $18.50 per ton and $46.40 per ton, respectively. The cost of operators' time, $300 per week, includes overhead and is based simply on a percentage of the total man hours worked by the operator. Utility costs average $15 per week. Maintenance costs, analytical costs, and amortization of the initial investment in the treatment plant are not included as a part of the treatment costs. Thus, the total expenditure for the initial forty-seven weeks of plant operation was $21,500. During this period 118.7 million gallons of waste were treated. The cost per 1000 gallons of waste treated was $0.18.

CONCLUSION

The process waste treatment plant has demonstrated that the lime-soda softening process is an effective and economical method for the removal of strontium and the total rare earths from large volumes of low-level waste. Cesium can be removed from these wastes by the addition of clay in the process.

The full potential of this plant in controlling the discharges to White Oak Creek is dependent upon a reliable automatic monitoring and diversion system. The times of increased levels of contamination in the process waste stream are difficult to predict, and, unless all higher levels are selectively diverted for treatment, excessive activities may bypass the plant. During the first five months of operation the automatic control valve was not in service, and the plant was operated only five days a week. Sixty-six per cent of the waste was bypassed to the Creek on a predetermined time schedule. Analyses of samples during this preliminary period indicate that the reductions of radioactivity in discharges to the Creek were not as great as should have resulted if all of the higher levels of waste had been treated before discharge.

The experience in operation to date indicates that this facility will fulfill the primary purpose of increasing the factor of safety in the control of radioactive wastes released to the Clinch River. Designed especially for the removal of strontium, the plant has shown reductions of 80 to 90% of the strontium in the wastes that have been treated. The other radionuclides that have a significant, though less dominant, influence on the MPC values for water can be reduced 50 to 60%, or more. Finally, and of even greater importance, the treatment plant provides a system for detention and treatment of accidental or emergency releases which might exceed the capacity of the river.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the U. S. Public Health Service and the U. S. Army Engineer Research and Development Laboratories through personnel assigned to ORNL who did much of the work on water decontamination research and assisted in the evaluation of processes for use in this plant. The material contained herein includes work by H. H. Abee, R. L. Newton, and H. J. Wyrick.

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DESIGN DETAIL FOR INDIVIDUAL SEWAGE DISPOSAL SYSTEMS[a]

Closure by Harrison A. Martin

HARRISON A. MARTIN,[1] M. ASCE.—It appears from the discussion of Mr. Finaly that it would have been well to include with the paper on the design of the Individual Sewage Disposal, a set of definitions on some of the terms used which may be somewhat obscure. These are as follows:

"Perk-Tester" as the name implies is a device for measuring the fall of the water during conduction of percolation test.

"mere convenience" has the classical dictionary meaning of —"nothing but—convenience". It is believed that read in context the meaning is clear.

"lid" and "hatches" have the classical dictionary meaning.

"fouling" has the classical dictionary meaning of—"impede", "choke" or use up the space provided for other purposes.

"seepage" and "leaching" mean the same and have their classical dictionary meanings.

A "seepage pit" sometimes called a "seepage well", "dry-well" or "leaching pit", is intended to be the same thing.

"Disposal bed" is a bed used for disposal of the clear efflux of the septic tank and is a bed of egg-shaped stones (egg size) about 1-1/2" (4 c.m. + or -) with disposal pipes, perforated fibre pipe or clay tile pipe (with open joints) laid over the stone or gravel bed.

"Disposal Field" is similar except that the pipes are laid in trenches, each separated from the other by a reasonable distance.

It is recommended that the preference be that the "Disposal Pit" be given the first consideration and if that would not work, then the Disposal Field may be used and for large installations the Disposal Bed is the writer's practice. The Disposal Pit will often be found not to have enough seepage or absorbing area. In that event it is necessary to resort to the Disposal Field or the Disposal Bed. The writer has constructed large "Disposal Pits" (20 ft. or more in diam.) (6.5 m.) for food dispensing establishments (soda fountains, etc.) and found them to be very satisfactory. The capacity as that of a tank, is advantageous. The "Pit" is more readily constructed by inexperienced workmen.

The number of blocks in the estimate on pages 8 and 9 of Proc. Paper 1715 is in error. The actual number of blocks should be 204 instead of 188. This was an error in the original manuscript.

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a. Proc. Paper 1715, July, 1958, by Harrison A. Martin.

1. Cons. Engr., H. A. Martin and Associates, Shrewsbury, N. J.

The "Percolation Test" is at best an approximation. Every engineer is aware that the falling of water in a hole is not at an even rate, the rate of the fall of the water would vary. Likewise, the absorption of the water in the hole in the earth would also vary. The two variables, as Mr. Finaly has so ably pointed out would lead to error.

As an approximation the percolation test, as made according to the instructions given, arbitrary and empirical though it may be, does furnish an excellent measure proportionate to the amount of water the earth at that very point and at that very elevation will absorb.

It is the writer's practice to bore a hole with an earth auger for the percolation test about 8-inches (19.5 cm) in diameter, dampen the hole well (fill it and let the water disappear) and keep filling until saturation is obtained (this usually takes hours). After the earth is saturated, fill the hole again to the point at which the actual percolation is to take place in the disposal field, bed or pit. This gives an empirical measure of the amount of water that the earth will take but does not take into account variations in evapotranspiration, heat of the earth, heat of the sun on the earth, wet bulb thermometer temperature, damage to hole (for this purpose) in boring the hole, barometric pressures and numerous other things which are neglected for convenience.

The practice here is to measure the water column from a fixed point at ground level. If the water in the sewage disposal is supposed to leach or seep at 18-inches (45 cm) depth, the test is made between 18-inches and 24-inches (61 cm). Many kinds of measures have been used but it has been found that a great deal of error can arise over lack of a permanent mark if the men are measuring numbers of holes. A device for measuring the depth that has a level bubble and an adjustable metal (non-corroding) rod for measuring works the best. This may be set over the hole on bricks or blocks which are leveled.

The fall of the column of water will not be the same for each inch of the six inches measured. Actually the rate of fall for the last inch will always be different than that of the first inch and somewhat longer time. The test is arbitrary and empirical but the best that has been devised and it produces results that are most valuable.

The writer, as a minor health official, has had occasion to review the design of thousands of Individual Sewage Disposals prior to construction and the Percolation Test has been the means of determining the size and kind of disposal to be used. Some cautions may be mentioned; never try to make a percolation test when the temperature is below freezing or the ground is frozen, take time to saturate the ground, make the test at the location that the sewage disposal is intended to percolate.

Lately the writer has acquired printed forms for the recording of the percolation test, called "PERCOLATION TEST REPORTS" which are transparencies and blue prints are made from them for issue to health authorities and others. Such forms prevent the leaving out of important data. (Fig. 1)

Mr. Finaly's observation that there is a discrepancy in the footnote on Item A, marked with asterisk, is again a question of definition, it should have been written "Electric Dish Washer" and there would not have been any confusion. A dish-washer in this country where labor is scarce is a machine.

Job No._____ **PERCOLATION TEST REPORT** Date of Test._____

Copyright 1955

DESCRIPTION
OF LOCATION:-_____
(Owner's Name & Address, Lot & Block Nos., Subdivision, Village, Borough)

Work ordered by:-_____

No. of Holes = ____ Weather:_____ EFFECT OF RECENT RAINS:_____

(Indicate depth of Ground Water on Hole Logs below.)

Ground Water encountered in Holes Nos._____

Ft.	Hole No. 1	Hole No. 2	Hole No. 3	Hole No. 4	Hole No. 5
0					
1					
2					
3					
4					
5					
TIME:	___Min.___Sec	___Min ___Sec	___Min ___Sec	___Min ___Sec	___Min ___Sec.

Ft.	Hole No. 6	Hole No. 7	Hole No. 8	Hole No. 9	Hole No. 0.
0					
1					
2					
3					
4					
5					
TIME:	___Min. ___Sec	___Min ___Sec	___Min ___ Sec	___ Min ___Sec	___ Min ___Sec.

Time is the rate of fall
in minutes & seconds per inch.

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PROPOSED CHANGES IN EASTERN WATER USE POLICIES[a]

Discussion by Thomas M. Stetson

THOMAS M. STETSON,[1] A. M. ASCE.—Mr. Stein has presented an interesting and timely discussion of the proposed changes in water use policies based on the Model Water Use Act drafted by the National Conference of Commissioners on Uniform State Laws. Drafting a water use act which would fit the needs of all of the 49 states of this nation is manifestly an insurmountable task. The Model Water Use Act, prepared by the Legislative Research Center of the University of Michigan Law School, is a valuable contribution to all states and is intended to provide a model from which any state could draft its own water use act.

State water rights doctrines are basically riparian, prior appropriation, or both. The quantity and distribution of annual rainfall in a state acts as a fulcrum influencing the basic water rights doctrine for each state. To date the eastern states, with annual precipitation usually in excess of 30 inches, are primarily riparian states. Conversely, states in which the annual precipitation ranges from less than 10 up to 20 inches, are primarily prior appropriation states. Some states, usually those in which the range in precipitation varies through wide limits from one area of the state to another, have adopted both doctrines.

Mr. Stein speaks of "the riparian or reasonable use doctrine which is prevalent in the East." It must be borne in mind that the prior appropriation doctrine, too, is based on reasonableness of use. A basic element of an appropriative right is that it attaches only to so much water as the appropriator can reasonably put to beneficial use. The primary difference between appropriation and riparianism takes place when reasonable needs of users exceed the supply. Until that point is reached, in fact, choice between water law doctrines has very little importance. Under riparianism, the newest user and the user with the oldest project are required to prorate their uses on the basis of apportionment worked out on a case to case basis. Under appropriation, the shortage falls on the last initiated water right. Attempting to divide water among all users, while it has the attractiveness of equality, actually tends to make a water right unprofitable to any, particularly where large investments in water use projects are required. Mr. Stein also states that under the riparian doctrine running water is not susceptible to unqualified ownership. This is equally true under the doctrine of prior appropriation. Under neither doctrine does the right attach to the corpus of the water, but only to its beneficial use.

a. Proc. Paper 1777, September, 1958, by Murray Stein.

1. Cons. Engr., Los Angeles, Calif.

The riparian doctrine, by its very nature, limits the areas where water can be used. On the other hand, the prior appropriation doctrine does not limit the areas where water can be used. For that reason, the prior appropriation doctrine tends to accelerate water resource development.

The Model Water Use Act proposes a permit system. Those riparian uses which are presently being exercised would be preserved by permits. Unused rights on riparian lands would be lost. Future water uses on those lands would also be subject to the permit system. The permis system proposed is more like the prior appropriation system than the riparian system. Owners of riparian lands who have not yet used water would have to stand in line with the rest to get their permits.

A major defect of the Model Water Use Act is the time limitation of the permit. The Model Act suggests 50 years. Many projects in the West, especially those sponsored by the federal government, cannot repay their construction costs during a 50 year period. Although there have been more than one-hundred Reclamation projects constructed or now under construction since the passage of the Reclamation Act of 1902, not one has returned its entire reimbursable construction cost.(1) The original repayment period under the 1902 Act was 10 years. At present the law provides for repayment of reimbursable irrigation features after completion of construction, within 40 years after a development period not to exceed 10 years. Aside from financing, however, limiting all water rights to 50 or any other stated number of years would be like limiting land titles to a stated duration.

The Model Act also contains a preference feature. Permits are to be granted with a view to "the most beneficial use and development of the water resources of the State." Determining the "most beneficial use" of water would be subject to much dispute. This is an invitation to the commission to play God. Just what is the best use of our water resources: domestic, industrial, agricultural, navigation, recreation, fish and wildlife, or some other use? Determining the most beneficial use of our water resources would lead to endless litigation. Economic factors alone could not control the most beneficial use. In fact, it is doubtful that any single factor, with the exception of sustaining life, could control the determination of the most beneficial use.

Section 407 of the Model Water Use Act provides that a permit may be granted " . . . if: (1) there is water available for use or for impounding . . ." However, the act provides no basis for determining the criteria which would establish the fact that "water [is] available for use or for impounding." Does this mean probably available? Possibly available? Available in some years? Available in all years? This same defect is common to the law of prior appropriation states. For instance, the law of California specifies that unappropriated water must be available, but neither statutes nor cases(2) define what is meant by "available."(3) There are no definite legal criteria by which to determine availability of unappropriated waters of a stream in California. Presumably an appropriation may be made for the infrequent flood flow of any stream.

The Model Water Use Act is designed primarily for the eastern states, but it would be up to each state to determine its own peculiar water supply and demand problems before it adopts an act based on the model. In most instances there are a sufficient number of alternates under each section of the act that one alternate would apply to the specific problems of any single state. It should be remembered, however, that no water right doctrine is perfect for

all areas of any state and it would take a number of years of operation under any act to work out the inherent inequities.

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RESISTANCE OF SEWAGE SLUDGE TO FLOW IN PIPES[a]

Discussion by Shu-t'ien Li
Corrections to the discussion by M. B. McPherson

SHU-T'IEN LI,[1] M. ASCE.—Being directly in the distinguished hydromechanics lineage of Osborne Reynolds—A. H. Gibson, the author is eminently qualified to treat of the hydraulics of sewage sludge and has made a notable advancement in this branch of fluid mechanics as evidenced by his proposed new approach. The nature of the subject is more hydraulic than sanitary. Had the paper been published in the Journal of the Hydraulics Division, it might have aroused wider discussion of fundamental character. With the author's paper as a basis, an effort could be well spent to incorporate certain necessary mathematico-physical improvements so as to lay the thesis on a firmer foundation for further research.

Nomenclature and Dimensional Analysis

The author defines W as specific weight of water in lb per cu ft, ρ as specific weight of sludge in lb per cu ft, μ as coefficient of viscosity in lb per ft per sec, and η as coefficient of rigidity in lb per ft per sec. From the engineer's point of view, such definitions might seem expedient, but they are plausible and very likely bring into the formulations fundamental inconsistencies.

In the lb-ft-sec system of units, for instance, by applying dimensional analysis to the author's Eq. (1), one readily sees

$$R = \frac{\rho V D}{\eta} \rightarrow \frac{\rho V D}{\mu} \text{ in } \left(\frac{lb}{ft^3}\right)\left(\frac{ft}{sec}\right)\left(\frac{ft\text{-}sec}{lb}\right)(ft)$$

$$= \text{a dimensionless parameter}$$

as it should be by definition of Reynolds' Number. Though the author's expedient units work well here, he would find immediately that his nomenclature will cause non-homogenuity in Eq. (2), not because of the original formulation of that equation but rather because of the author's nomenclature. Again, applying dimensional analysis to Eq. (2), using the author's nomenclature, it can be shown that the originally homogeneous equation

$$\mu = \eta + \frac{16 S_y D}{3V} \text{ would be in}$$

a. Proc. Paper 1780, September, 1958, by Tsung-Lien Chou.

1. Chf. Technical Writer, Palmer and Baker, Inc., Cons. Engrs., Mobile, Ala.

$$\frac{lb}{ft\text{-}sec} = \frac{lb}{ft\text{-}sec} + \frac{Numerical\ Constant}{Numerical\ Constant}\left(\frac{lb}{ft^2}\right)\left(\frac{sec}{ft}\right)(ft)$$

$$= \frac{lb}{ft\text{-}sec} + \frac{lb\text{-}sec}{ft^2}$$

which clearly indicates that the two terms on the right-hand side now cannot be added because they have become different composite units just as different simple units like lb, ft, and sec cannot be added.

It is of utmost a priori importance that in all mathematico-physical formulations, whether rational, semi-rational, or empirical, any logical equation in its simplest form must be dimensionally homogeneous. This very fact should be mathematically extended for determining the appropriate forms of empirical equations deduced from experimental data. A more rational approach would consist of formulating the appropriate forms of equations by theoretical derivation and dimensional analysis and determining the constant or variable coefficients by well planned and designed experiments.

The earliest statement about the general requirement of homogeneity was apparently enunciated by the French mathematician and physicist, Baron Jean Baptiste Joseph Fourier (1768-1830) in 1922. Later, British mathematicians and physicists, Sir George Gabriel Stokes (1819-1903), Lord John William Strutt Rayleigh (1842-1919), Sir Joseph John Thompson (1856-1940), and Osborne Reynolds evolved methods of dimensional analysis. A much more complete principle of dimensional analysis was postulated in France by A. Vaschy in 1892, but has scarcely been known in the English-speaking countries. In 1914 and 1915, Edgar Buckingham proposed his TP Theorem, now generally recognized as "Buckingham's TP Theorem," or "Method of Buckingham," or "The Buckingham Method." It is mathematically similar in principle to Vaschy's method.

Now, returning to Eq. (2) for further consideration, it can be shown that this original equation of W. D. Hatfield, published in Sewage Works Journal, Vol. 10, 1938, is homogeneous if the author had used the universally recognized nomenclature in the pound-foot-second system in which the relevant terms should be defined thus:

w = specific weight of water in lb per cu ft

ρ = density of water in mass units of slugs per cu ft = $\frac{w}{g}$ in $\frac{lb\text{-}sec^2}{ft^4}$

w_s = specific weight of sewage sludge in lb per cu ft

ρ_s = density of sewage sludge in slugs per cu ft = $\frac{w_s}{g}$ in $\frac{lb\text{-}sec^2}{ft^4}$

μ = coefficient of viscosity of water in $\frac{lb\text{-}sec}{ft^2}$

μ_s = coefficient of viscosity of sludge in $\frac{lb\text{-}sec}{ft^2}$

η = coefficient of rigidity of sludge in $\frac{lb\text{-}sec}{ft^2}$ when the moisture content is below M_1.

It is imperative that the composite unit for the coefficient of viscosity should be in lb-sec/ft^2 instead of the author's lb/ft-sec. This can be shown by combining the qualitative physics, the quantitative mathematics, and dimensional analysis of viscosity. In the physical sense, viscosity is primarily due to cohesion and interaction between fluid molecules, and, as flow occurs, these effects appear as tangential or shearing stresses between the moving fluid layers. Observations show that there is no velocity at the boundary and that velocity increases at increasing distance from the boundary. Thus there exists between any two adjacent layers a relative motion and hence frictional action which may be expressed as a shearing or frictional stress per unit of contact area. Let τ represent this stress in lb/ft^2. It has been found for non-turbulent flow, in which viscosity plays an important role, to be proportional to the rate of change of velocity along any line normal to the boundary. If y is any distance in feet on any normal from the boundary, then the quantitative mathematics becomes

$$\tau \propto \frac{dV}{dy}$$

and the "coefficient of viscosity" μ is defined as the constant of proportionality in the above equation such that

$$\tau = \mu \frac{dV}{dy}$$

The dimensions of the coefficient of viscosity may now be derived from dimensional homogeneity as

$$\text{Dimensions of } \mu = \frac{\text{Dimensions of } \tau}{\text{Dimensions of } \frac{dV}{dy}} = \left(\frac{lb}{ft^2}\right)\left(\frac{ft}{\frac{ft}{sec}}\right) = \frac{lb\text{-}sec}{ft^2}$$

which checks with the writer's nomenclature for μ in its units.

With the writer's nomenclature, it can be shown by dimensional analysis that the author's Eq. (1) will have

$$R = \frac{\rho V D}{\mu} \text{ in } \left(\frac{lb\text{-}sec^2}{ft^4}\right)\left(\frac{ft}{sec}\right)\left(\frac{ft^2}{lb\text{-}sec}\right)(ft)$$
$$= \text{a dimensionless parameter}$$

and that Eq. (2) will have

$$\mu = \eta + \frac{16 S_y D}{3V} \text{ in}$$

$$\frac{lb\text{-}sec}{ft^2} = \frac{lb\text{-}sec}{ft^2} + \left(\frac{lb}{ft^2}\right)\left(\frac{sec}{ft}\right)(ft)$$
$$= \frac{lb\text{-}sec}{ft^2} + \frac{lb\text{-}sec}{ft^2}$$

indicating all terms in like composite units. Not only the right-hand terms are additive, but also the entire equation is homogeneous.

The above analysis conclusively shows that the author's units for η, ρ and μ under his nomenclature are inconsistent and should be revised.

There are available simpler units for η, ρ, μ, based on ρ in slugs per cu ft as defined by the writer. Since

$$\rho = \frac{w}{g} \quad \text{in} \quad \frac{\text{slugs}}{\text{ft}^2} = \left(\frac{\text{lb}}{\text{ft}^3}\right)\left(\frac{\text{sec}^2}{\text{ft}}\right)$$

$$\text{then} \qquad \text{lb} = \frac{\text{slugs-ft}}{\text{sec}^2}$$

$$\text{Therefore} \qquad \mu \text{ in } \frac{\text{lb-sec}}{\text{ft}^2} = \left(\frac{\text{slugs-ft}}{\text{sec}^2}\right)\left(\frac{\text{sec}}{\text{ft}^2}\right) = \frac{\text{slugs}}{\text{ft-sec}}$$

showing that the author would be right and Eqs. (1) to (7) would be consistent and homogeneous if he had simply replaced "pounds" by "slugs" in his nomenclature for η, ρ, μ, and called ρ "density" instead of "specific weight." The rule that "The terms must be correctly defined," once again proves its infallible truth here. According to the corrected nomenclature, the author's $\rho = 62.4$ G, under (A), p. 1780-4, should become $\rho = \frac{62.4G}{g}$, and η values in his Fig. 3 should be transformed to slugs per ft per sec.

Head Losses of Flow in Suspension

The author's Eq. (8) is again not in homogeneous form, since

$$\frac{H}{L} = \frac{\mu V}{\rho D^2}$$

should be dimensionless on both sides, but the right-hand side is in ft/sec^2 either according to the author's nomenclature or according to the corrected nomenclature. From the point of view of dimensional analysis, one can instantly infer that there must be a "g" in the denominator and another numerical constant on the right-hand side. The author would be right if he had written it as

$$\frac{H}{L} \propto \frac{\mu V}{\rho D^2}$$

In laminar flow through pipes, it can be proved (see any modern standard work on fluid mechanics) that, using the corrected nomenclature,

$$\frac{H}{L} = \frac{32 \mu V}{w D^2}$$

which is dimensionally in

$$\frac{ft}{ft} = \left(\frac{lb\text{-}sec}{ft^2}\right)\left(\frac{ft}{sec}\right)\left(\frac{ft^3}{lb}\right)\left(\frac{1}{ft^2}\right)$$

showing both sides dimensionless and hence homogeneous. Therefore, the author's Eq. (8) should be changed to read

$$\frac{H}{L} = \frac{32\mu V}{wD^2}$$

His Eq. (8) would be approximately correct, but only numerically, not diminsionally, if he had defined ρ in the composite unit of $\frac{\text{lb-sec}^2}{\text{ft}^4}$.

Head Loss of Plastic Flow in Laminar Stage

According to the author's nomenclature, neither the second term on the right-side of Eq. (10), nor the like term of Eq. (11), is homogeneous with the other terms. By the corrected nomenclature, however, ρ in Eq. (11) should be changed to W_s, and both equations become homogeneous throughout. Thus, Eq. (11) will be logically valid when it is written, using the corrected nomenclature, as

$$\frac{H}{L} = \frac{16S_Y}{3W_sD} + \frac{\eta V}{W_sD^2}$$

Head Loss of Plastic Flow in Turbulent Stage

The author brings out the friction factor "f" in Darcy's formula corresponding to Reynolds number R. Specifically, how do they correspond can be proved as

$$f = \frac{64\mu}{\rho VD} = \frac{64}{R}$$

where μ and ρ are according to the corrected nomenclature. Thus f and R are inversely proportional.

In discussing Greenwich experiments by Sterling G. Brisbin, M. ASCE, the author refers to Hazen-Williams' formula. This exponential formula is an outstanding example of dimensionally non-homogeneous empirical equation of the old school. Modern technological advance does not tolerate likewise.

Further Remarks on Nomenclature

Throughout the above discussion, an effort has been made to bring into the author's equations complete homogeneity by correcting only the definitions and composite units of the nomenclature without radically modifying the formulations. This is the simplest possible way of putting the author's equations on a firm foundation. The author has, however, the right to keep his

nomenclature, but in which case he would have to introduce conversion factors to reduce those non-homogeneous terms into homogeneous ones.

The Avenue of Rheological Theory

Just as much as the design theory of today in suspension bridges has been rationalized by "The Aerodynamic Theory of Suspension Bridges" advanced by Dr. D. B. Steinman, M., ASCE, the thesis of the author might be advanced by "The Rheological Theory of Sewage Sludge." It is the science of "Rheology" that treats of the study of the mechanics of the flow of liquids and suspensions. The name Rheology was chosen by Professor John R. Crawford of Lafayette College, Pa. The Society of Rheology, affiliated with the American Institute of Physics, was founded in 1929. In 1930 in the Journal of Rheology, E. C. Bingham defined rheology as the study of the flow and deformation of matter. The name is compounded from "Rheo" (flow) and "Lagos" (theory).

Under the light of this new science of rheology, liquids and suspensions of solids in liquids are divided into two general classes: (A) Newtonian, and (B) non-Newtonian.

(A) Newtonian liquids or suspensions are characterized by a constant viscosity, independent of the rate of shear. The pressure drop can be computed by the Poiseuille equation for viscous flow and the Fanning equation for turbulent flow, using the density and viscosity of the liquid or suspension.

(B) Non-Newtonian suspensions are classified according to the general type of functional dependence of shear stress on the rate of shear, that is, according to the general type of shear diagram, into five general types: (1) Bingham plastic, (2) Pseudoplastic, (3) Dilatant, (4) Thixotropic, and (5) Rheopectic.

(1) Bingham Plastic.—This type of suspension shows a shear diagram consisting of a straight line with a positive intercept on the shearing stress axis. The intercept is called the "yield stress," Sy, using the author's nomenclature. The inverse slope of the curve is equal to the "coefficient of rigidity," η.

(2) Pseudoplastic.—This type of suspension has a shear diagram starting at the origin and generally approaching a straight line at high rates of shear. The apparent viscosity decreases with increasing rate of shear. The inverse slope of the straight line is the apparent viscosity at infinite rate of shear. The inverse slope of the curve for very low rates of shear is constant and called the apparent viscosity at zero rate of shear.

(3) Dilatant.—This type of suspension produces a shear diagram which is the opposite of a pseudoplastic suspension. The apparent viscosity increases with increasing rate of shear. "Dilatancy" was discovered and named by the author's professor Osborne Reynolds in ca. 1885 as recorded in his "Scientific Papers," Vol. II, 1901, Cambridge University Press.

(4) Thixotropic.—This type of suspension possesses a structure of which the breakdown is a function of time as well as of the rate of shear. The structure can rebuilt itself, if it is not prevented from doing so by externally applied forces. The name was derived from two Greek works meaning "to change by touching." The phenomenon was named "Thixotropy" around 1927 by Peterfi and Freundlich, and

it was defined ca. 1934 by the latter as the isothermal gel-sol-gel transformation upon agitation and subsequent rest.

(5) Rheopectic.—This type of suspension will take place by rhythmically shaking or tapping certain thixotropic suspensions, and will set, or build up its apparent viscosity, very rapidly. This phenomenon was called "rheopexy" by Freundlich and Juliusberger in ca. 1935. The name was derived from "Rheo" (to flow) and a Greek word meaning, "solidified," or "curdled." A rheopectic material exhibits the opposite of a thixotropic material; that is, its apparent viscosity increases with time at any constant rate of shear.

Without going into the mathematical analysis of the flow of liquids and suspensions under the new science of rheology, the above introduction to this branch of knowledge serves to indicate that sanitary and hydraulic engineers inquiring into the "resistance of sewage sludge to flow in pipes" could be benefitted by the advancement made in the avenue of rheological theory and its associated experimental research and mathematical analysis.

Sewage sludge in its broadest sense in highly industrialized communities may be dominated by any of the Newtonian or non-Newtonian classes and types of liquids or suspensions.

Just as sanitary engineers have already been aware of radioactive pollution, rheological studies are nonetheless important to them.

Concluding Remarks

The author is to be highly commended for his proposed new approach to, and for his systematizing the meager data on, the subject. As much heterogeneous and variable are the available data as the nature of sewage sludge. So were also the originally scattered treatments of the subject. To unify such treatments under a single system of nomenclature is liable to create non-homogeneity.

To bring all of the author's equations into complete homogeneity, the writer has applied dimensional tests and suggested the revision of a few terms under nomenclature and slight changes in the equations. In fact, all the equations can be logically formed by solving simultaneous dimensional-analysis equations.

More classification of types of flow will narrow down the range of experimental determination. To this end, an introduction to modern rheological studies is made. This avenue will open a new vista to sewage-sludge flow in pipes.

M. B. McPHERSON,[1] A. M. ASCE.—In the discussion which appeared in SA 2, March, 1959, Proceedings Paper No. 1985, p. 115, there has been an omission in the second full paragraph on p. 115, as separated by brackets in the following sentence: "Assuming that pressure is hydrostatically distributed in a vertical plane of the flow section, or $\partial p/\partial \ell$ is a constant, a linear variation in shear stress from the outer edge of the "plug" [to the pipe wall is indicated; the shear stress within the "plug"] must be constant and equal to the yield value (it was erroneously shown decreasing linearly to zero at the

1. Research Engr., Philadelphia Water Dept., Philadelphia, Pa.

center of the pipe on p. 13 of the reference, but the derivation leading to Mr. Chou's Eq. (10) did not involve this error and is correct)."

SLEUTHING THE BEHAVIOR OF A RIVER[a]

Discussions by G. E. Walker and Bernd H. Dieterich

G. E. WALKER.[1]—So far as the River Thames is concerned, the problems apparently are not nearly as great or numerous as those being met and dealt with on the Ohio River, the main reason being that the Conservators have operated their Statutory Powers for the control of pollution for over 100 years, so that the population in the Thames area have been educated up to becoming pollution conscious.

However, vigilance is in no way relaxed and a staff of Inspectors maintain constant watch on the main stream of the Thames and all watercourses connecting directly or indirectly with that River within the 3,845 square miles of the Conservators' area. In addition, all towns, villages and other centres of population are inspected and the sewage disposal works in operation, as well as factories and other premises, farms and outlying properties, the drainage from which is likely to pass to a watercourse.

Fortunately, the direct discharge of manufacturing wastes to our streams has been considerably reduced over the years by connection to the soil sewers. Cesspools and other primitive forms of disposal, which collectively in the past have caused much pollution, are now being superseded by systems of main drainage. Gas production has mostly been centralized and many individual gas works, always potential sources of serious pollution, have ceased to operate.

A very considerable amount of work is going forward in connection with the provision of new sewage disposal works and the improvement of existing works.

It is the effluents from the many sewage works within the Conservators'. area that are our main concern. Samples of these effluents are taken regularly and submitted to the Conservators' Analyst. In each case where an adverse report on a sample is received, the matter is taken up at once with the Local Authority or person responsible.

The Conservators' policy is to endeavour, as far as possible, to obtain cessation of pollution—from sewage works and other sources—by persuasion and in this they have been very successful. Failing this, Statutory Notices may be served on the offenders requiring discontinuance of the pollution within three months. For non-compliance with a Notice and in the more serious cases, usual wilful pollution, proceedings may be taken. In addition to sampling the sewage effluents, river water samples are taken periodically and, at the last point of the river within the Conservators' jurisdiction, the water is sampled weekly. In all, over 2,000 samples of effluents and waters

a. Proc. Paper 1847, November, 1958, by Edward J. Cleary.

1. Secy., Solicitor, Parliamentary Officer, Thames Conservancy, London, England.

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are examined annually.

We do have occasional fish mortalities and anything of a serious nature is usually caused by some toxic materials being disposed of illicitly into surface water systems. More frequently, fish are killed in the tributaries during conditions of low flow and hot weather when the oxygen content of the water is very seriously depleted.

Whatever the cause, however, samples of river water are taken above and below where the dead fish are found, also samples of any discharges in the vicinity. In addition, specimens of the fish are submitted to a biologist for examination.

The effect of our endeavours for the control of pollution is that, on chemical analysis, the River Thames water continues to be generally satisfactory; and the importance of this work cannot be too strongly stressed when it is realised that approximately two thirds of the total quantity of water supplied daily to London is taken from the River Thames within the Conservators' area.

BERND H. DIETERICH.[1]—There exists but one major German parallel to the work which has been described by Mr. Cleary, i.e. the stream surveillance program along the Rhine River.

Within Germany the Rhine River drainage area covers 36,800 sq. miles. It cuts into territory of 6 of the 11 German states: Bayern, Baden-Wuerttemberg, Hessen, Nordrhein-Westfalen, Rheinland-Pfalz, and Saarland. The German population of this area amounts to 24,461,000; i.e. 46% of the total population of the Federal Republic of Germany. Some 70% of the gross national income and around 70% of the public and industrial water supplies of Germany are concentrated in this part of the country. Consequently, 70% of the sewage and industrial wastes from German communities and industries are discharged into the Rhine River. The total of 4040 mgd waste water amount to 8,0% of the mean annual flow or 19,5% of the minimum annual flow of this river at the Dutch/German border.

However, the resulting pollution of the Rhine River is more than a national problem only. Five countries discharge waste water into this water course: France, Germany, Holland, Luxembourg, and Switzerland. Fig. 1 gives an impression of this complex situation. Typical contributions of France, Germany, Luxembourg and Switzerland to the Rhine River drainage area are (there is actually a Dutch Rhine irrigation area but no Dutch Rhine drainage area):

	Population	Area (Sq. Mi.)	Long Range Mean Annual Flow (cfs.)
France	2,935,000	10,300	11,800
Germany	24,641,000	36,800	39,400
Luxembourg	299,000	1,000	1,100
Switzerland	3,641,000	9,000	22,800

1. Chief, Stream Sanitation Section, Water Management Div., Federal Dept. of Atomic Energy and Water Management, Bonn, Germany.

North Sea
Baltic Sea
Elbe
Ems
Weser
Holland
Nordrhein-
Westfalen
Hessen
Rhine
Sampling stations
Rhine drainage area
International borders
State lines
Luxem-
bourg
Moselle
Rheinland-
Pfalz
Saar-
land
Main
Bayern
France
Baden-
Wuerttemberg
Danube
Switzerland
Austria
0 20 40 60 80 100
Miles

Three major problems result:

(1) Organic pollution affects German and Dutch water supplies along the lower part of the Rhine River.

(2) Tastes and odors from oil (navigation) and industrial wastes severely affect and frequently upset German and Dutch water supplies.

(3) Chlorides from potassium and hard coal mining affect irrigation in Holland (about 10% of the mean annual flow of the Rhine are diverted into the Zuider Sea for irrigation purposes).

To control stream pollution national and international cooperation has been established. The German federal government and the respective 6 German states are now forming a joint commission. This commission coordinates stream sanitation programs which are designed and enforced by the state governments. Moreover, the "International Commission for the Protection of the Rhine River against Pollution" exists since 1952. The international commission functions as an investigating and advisory body. Its chairman is, at present, Professor O. Jaag of Switzerland. Each of the 5 countries is represented by 2 delegates and a number of technical experts. A secretariat has been established at the Engineering College in Zurich; among its members are Dr. K. Wuhrmann and Dr. F. Zehender.

To provide data for further stream pollution control programs the international commission has begun a stream surveillance program which includes 10 sampling stations (see Fig. 1). An agreement has been reached on the applicable standard methods for the examination of the water. The samples are taken by national laboratories twice a month. The measurements include pH, dissolved oxygen, chlorides, phenols, hardness, and radioactivity. All results are published by the international commission. Some data, especially on chlorides are given in mg/1 and kg/sec. The total amount of chlorides in kg/sec is significant to Dutch engineers because the irrigation water is stored and equally mixed in the Zuider Sea. Including underground-seepage and leekage through docks, the Dutch allow a mean concentration of 300 mg/1 chlorides in the Zuider Sea. Higher concentrations reduce crop yields.

Typical results at or near the Dutch/German border are (mean values 1955/1956):

Flow	72300 cfs
Dissolved oxygen	7.23 mg/1
Oxygen saturation	66%
Chlorides	138.1 mg/1
"	242.2 kg/sec
Phenols	0.0441 mg/1

Some data are presented in Fig. 2. In the reports, the international commission has chosen several different schemes of graphical representation.

Long range data are collected on flow values. They are used to predict the flow behavior of the river. Five duration curves are given in Fig. 3.

Of great importance is the development of chloride pollution. For the past five years the annual mean values of chloride pollution have been analysed statistically. The correlation coefficients and the annual increase in chlorides are:

Sampling Station or Part of River	Correl. Coeff. r	Correlation	Annual Increase in Cl^- - Pollution or Cl^- - Discharge, kg/sec
Between Stat. 2 and 3	0.94	Significant	12.3
Between Stat. 3 and 4	0.16	Insignificant	(1.2)
Between Stat. 4 and 4a	0.88	Significant	1.7
Between Stat. 4a and 6	-0.41	Insignificant	(-2.1)
At Station 6	0.81	Significant	12.6

The statistical reliability of the correlation coefficient has been tested on a 90%-confidence limit. Statistical correlation only exists for chloride discharge between stations 2 and 3, and between stations 4 and 4a, and for chloride pollution at station 6.

It is proposed that the surveillance program is continued for record purposes. Since the measurements are carried out by the respective national laboratories and because there are practically no regular staff members, the budget of the international commission is kept at minimum.

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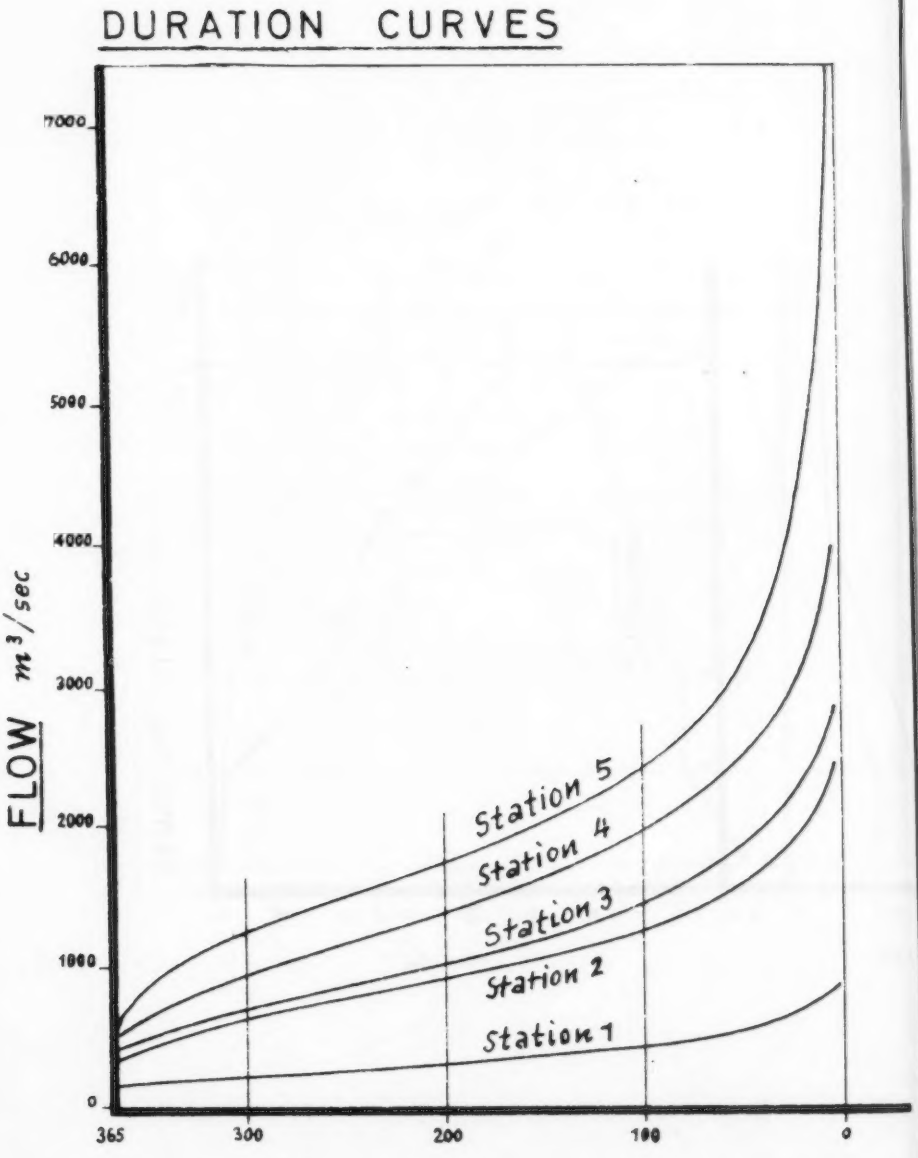
RHINE WATER DATA
(June 1955 - June 1956)
Flow
maximum flow 1993/38
maximum flow
mean flow
minimum flow
minimum flow 1933/58
m³/sec
Dissolved oxygen
mean
mg/l

Dissolved oxygen
Mean
Minimum
mg / l
Chlorides
Maximum
Mean
Minimum
kg / sec
Sampling Stations
1
2
3
4
6/7
8+9+10


DURATION CURVES
FLOW m³/sec
7000
6000
5000
4000
3000
2000
1000
0
Station 5
Station 4
Station 3
Station 2
Station 1
365
300
200
100
0
Days with flow greater than given values

MUNICIPAL COMPOSTING IN THE UNITED KINGDOM[a]

Discussion by Philip H. Perkins

PHILIP H. PERKINS,[1] M. ASCE.—Mr. Gordon should be congratulated on a very interesting paper on a subject which has been very much neglected both in the United Kingdom and in most other countries with the possible exception of Holland and Denmark.

Mr. Gordon did not mention the pulverising plant at Southwark in London, which the writer has always considered as the first serious attempt by a Municipal Authority to convert town refuse into an agricultural fertiliser.

Mr. Gordon also did not give any details of the costs of the "Dano" plants at Edinburgh which he mentioned on page 1852-27. About two years ago, the Engineer/Manager of the Lighting and Cleansing Department of the City of Edinburgh sent the writer some detailed information on this matter, and these figures are shown in the accompanying table. A comparison of the costs of the Kirkconnel and Jersey plants with the costs of the experimental "Dano" plant and the expected costs of the proposed new "Dano" plant (now under construction) at Edinburgh, are shown on the attached schedule.

It is appreciated that such comparisons can, on the surface be misleading, and that when the figures are examined in detail quite a different picture emerges; however, the writer would be very interested to hear Mr. Gordon's comments on the above.

a. Proc. Paper 1852, November, 1958, by C. A. Gordon.
1. Civ. Eng. Cons., Cypress.

Plant	Annual Quantity of Crude Refuse Handled.	Capital Cost	Capital cost per ton of crude refuse per annum.	Annual Loan repayment over 30 years at 5%, per ton of crude refuse.	Loan Repayment per ton of Crude Refuse Handled.	Annual Operating Expenses.	Annual Operating Expenses per ton of crude refuse handled.
1. Kirkconnel (Mr. Gordon)	1839 tons	£30,000	£16.3	£1,950	£1.06	£2897	£1.75
2. Jersey (Mr. Gordon)	14,000 tons	£220,000	£15.85	£14,200	£1.00	£28200	£2.00
3. (a) Edinburgh, "Demo." (experimental)	2,200 tons	+ £ 41,000	+ £16.3	£ 2,634	£1.17	£2195	£1.0
3. (b) Edinburgh, "Demo." (Proposed)	27,500 tons	✦ £164,000	✦ £ 5.95	✦ £ 0,636	✦ £0.385	✦ £21,115	✦ £0.77

+ Estimated from loan repayment charges.

✦ "Expected" or "Estimated" costs.

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PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Department of Conditions of Practice are identified by the symbols (PP). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper number are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1859 is identified as 1859 (HY 7) which indicates that the paper is contained in the seventh issue of the Journal of the Hydraulics Division during 1958.

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MAY: 1621(HW2), 1622(HW2), 1623(HW2), 1624(HW2), 1625(HW2), 1626(HW2), 1627(HW2), 1628(HW2), 1629 (ST3), 1630(ST3), 1631(ST3), 1632(ST3), 1633(ST3), 1634(ST3), 1635(ST3), 1636(ST3). 1637(ST3), 1638(ST3), 1639(WW3), 1640(WW3), 1641(WW3), 1642(WW3), 1643(WW3), 1644(WW3), 1645(SM2), 1646(SM2), 1647 (SM2), 1648(SM2), 1649(SM2), 1650(SM2), 1651(HW2), 1652(HW2)[c], 1653(WW3)[c], 1654(SM2), 1655(SM2), 1656(ST3)[c], 1657(SM2)[c].

JUNE: 1658(AT1), 1659(AT1), 1660(HY3), 1661(HY3), 1662(HY3), 1663(HY3), 1664(HY3), 1665(SA3), 1666 (PL2), 1667(PL2), 1668(PL2), 1669(AT1), 1670(PO3), 1671(PO3), 1672(PO3), 1673(PL2), 1674(PL2), 1675 (PO3), 1676(PO3), 1677(SA3), 1678(SA3), 1679(SA3), 1680(SA3), 1681(SA3), 1682(SA3), 1683(PO3), 1684 (HY3), 1685(SA3), 1686(SA3), 1687(PO3), 1688(SA3)[c], 1689(PO3)[c], 1690(HY3)[c], 1691(PL2)[c].

JULY: 1692(EM3), 1693(EM3), 1694(ST4), 1695(ST4), 1696(ST4), 1697(SU2), 1698(SU2), 1699(SU2), 1700(SU2), 1701(SA4), 1702(SA4), 1703(SA4), 1704(SA4), 1705(SA4), 1706(EM3), 1707(ST4), 1708(ST4), 1709(ST4), 1710 (ST4), 1711(ST4), 1712(ST4), 1713(SU2), 1714(SA4), 1715(SA4), 1716(SU2), 1717(SA4), 1718(EM3), 1719 (EM3), 1720(SU2), 1721(ST4)[c], 1722(ST4), 1723(ST4), 1724(EM3)[c].

AUGUST: 1725(HY4), 1726(HY4), 1727(SM3), 1728(SM3), 1729(SM3), 1730(SM3), 1731(SM3), 1732(SM3), 1733 (PO4), 1734(PO4), 1735(PO4), 1736(PO4), 1737(PO4), 1738(PO4), 1739(PO4), 1740(PO4), 1741(PO4), 1742 (PO4), 1743(PO4), 1744(PO4), 1745(PO4), 1746(PO4), 1747(PO4), 1748(PO4), 1749(PO4).

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OCTOBER: 1790(EM4), 1791(EM4), 1792(EM4), 1793(EM4), 1794(EM4), 1795(HW3), 1796(HW3), 1797(HW3), 1798(HW3), 1799(HW3), 1800(HW3), 1801(HW3), 1802(HW3), 1803(HW3), 1804(HW3), 1805(HW3), 1806 (HY5), 1807(HY5). 1808(HY5), 1809(HY5), 1810(HY5), 1811(HY5), 1812(SM4), 1813(SM4), 1814(ST6), 1815 (ST6), 1816(ST6), 1817(ST6), 1818(ST6), 1819(ST6), 1820(ST6), 1821(ST6), 1822(EM4), 1823(PO5), 1824 (SM4), 1825(SM4), 1826(SM4), 1827(ST6)[c], 1828(SM4)[c], 1829(HW3)[c], 1830(PO5)[c], 1831(EM4)[c], 1832(HY5)[c]

NOVEMBER: 1833(HY6), 1834(HY6), 1835(SA6), 1836(ST7), 1837(ST7), 1838(ST7), 1839(ST7), 1840(ST7), 1841(ST7), 1842(SU3), 1843(SU3), 1844(SU3), 1845(SU3), 1846(SU3), 1847(SA6), 1848(SA6), 1849(SA6), 1850(SA6), 1851(SA6), 1852(SA6), 1853(SA6), 1854(ST7), 1855(SA6)[c], 1856(HY6)[c], 1857(ST7)[c], 1858 (SU3)[c].

DECEMBER: 1859(HY7), 1860(IR4), 1861(IR4), 1862(IR4), 1863(SM5), 1864(SM5), 1865(ST8), 1866(ST8), 1867 (ST8), 1868(PP1), 1869(PP1), 1870(PP1), 1871(PP1), 1872(PP1), 1873(WW5), 1874(WW5), 1875(WW5), 1876 (WW5), 1877(CP2), 1878(ST8), 1879(ST8), 1880(HY7)[c], 1881(SM5)[c], 1882(ST8)[c], 1883(PP1)[c], 1884(WW5)[c], 1885(CP2)[c], 1886(PO6), 1887(PO6), 1888(PO6), 1889(PO6), 1890(HY7), 1891(PP1).

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FEBRUARY: 1933(HY2), 1934(HY2), 1935(HY2), 1936(SM1), 1937(SM1), 1938(ST2), 1939(ST2), 1940(ST2), 1941(ST2), 1942(ST2), 1943(ST2), 1944(ST2), 1945(HY2), 1946(PO1), 1947(PO1), 1948(PO1), 1949(PO1), 1950(HY2)[c], 1951(SM1)[c], 1952(ST2)[c], 1953(PO1)[c], 1954(CO1), 1955(CO1), 1956(CO1), 1957(CO1), 1958 (CO1), 1959(CO1).

MARCH: 1960(HY3), 1961(HY3), 1962(HY3), 1963(IR1), 1964(IR1), 1965(IR1), 1966(IR1), 1967(SA2), 1968 (SA2), 1969(ST3), 1970(ST3), 1971(ST3), 1972(ST3), 1973(ST3), 1974(ST3), 1975(ST3), 1976(WW1), 1977 (WW1), 1978(WW1), 1979(WW1), 1980(WW1), 1981(WW1), 1982(WW1), 1983(WW1), 1984(SA2), 1985(SA2)[c], 1986(IR1)[c], 1987(WW1)[c], 1988(ST3)[c], 1989(HY3)[c].

APRIL: 1990(EM2), 1991(EM2), 1992(EM2), 1993(HW2), 1994(HY4), 1995(HY4), 1996(HY4), 1997(HY4), 1998 (SM2), 1999(SM2), 2000(SM2), 2001(SM2), 2002(ST4), 2003(ST4), 2004(ST4), 2005(ST4), 2006(PO2), 2007 (HW2)[c], 2008(EM2)[c], 2009(ST4)[c], 2010(SM2)[c], 2011(SM2)[c], 2012(HY4)[c], 2013(PO2)[c].

MAY: 2014(AT2), 2015(AT2), 2016(AT2), 2017(HY5), 2018(HY5), 2019(HY5), 2020(HY5), 2021(HY5), 2022 (HY5), 2023(PL2), 2024(PL2), 2025(PL2), 2026(PP1), 2027(PP1), 2028(PP1), 2029(PP1), 2030(SA3), 2031(SA3), 2032(SA3), 2033(SA3), 2034(ST5), 2035(ST5), 2036(ST5), 2037(ST5), 2038(PL2), 2039(PL2), 2040(AT2)[c], 2041(PL2)[c], 2042(PP1)[c], 2043(ST5)[c], 2044(SA3)[c], 2045(HY5)[c], 2046(PP1), 2047(PP1).

c. Discussion of several papers, grouped by divisions.

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Your attention is invited

NEWS OF THE SANITARY ENGINEERING DIVISION OF ASCE

JOURNAL OF THE SANITARY ENGINEERING DIVISION
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

DIVISION ACTIVITIES

SANITARY ENGINEERING DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

May, 1959

DIVISION ACTIVITIES

American Sanitary Engineering Intersociety Board Examinations Held

Examinations were held at 14 different locations throughout the United States during April and May for certification by the American Sanitary Engineering Intersociety Board.

The examination consisted of three parts, two written and one oral. These included basic science and specialty examinations. A nonrefundable fee of $25 was required for admission to the examination. The five recognized specialties include: Public Health, Water Supply and Waste Water Disposal, Industrial Hygiene, Air Pollution Control, and Radiation Hazard and Hygiene Control.

Philadelphia Section Sanitary and Hydraulics Division

The newly formed Sanitary and Hydraulics Engineering Division of The Philadelphia Section, ASCE, has progressed into its second year of activity with an interesting program. The guest speaker at the November Meeting was Mr. Jack Boardman of the Interstate Commission on the Delaware River Basin (INCODEL) who spoke on "Pollution Abatement in the Delaware River." The January Meeting consisted of a late afternoon inspection of the City of Philadelphia, Water Distribution System Analyzer and an evening session at which Mr. Max Barofsky and Mr. Ralph Hoot, both of The City of Philadelphia Water Department, spoke on The City of Philadelphia Sewerage System and Treatment. At the meeting held on March 19, 1959, a very timely subject titled "Radio Active Wastes Disposal" was discussed by Mr. Richard S. Mark, Asst. Regional Engineer, Region II, of the U. S. Public Health Service.

The subject of the meeting scheduled for May 21, 1959, will be "Population Projections for the Delaware River Basin."

Division officers for the current year are:

Professor Ronald V. Giles - Chairman
Mr. David E. Donley - Vice-Chairman
Mr. Walton Purdom - Secretary-Treasurer

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Nominations for officers for the year 1959 to 1960 will be presented for election at the May meeting. Participation in the division has grown considerably since its organization in 1957 and we are certain the division has a very promising future.

Did You Know That

William A. Cawley and Jay S. Grumbling have joined the staff of the Scranton Publishing Company as Associate Editors for Water & Sewage Works, Industrial Wastes, and Modern Highways magazines. Bill Cawley was previously Sanitary Engineer, New York Engineering Department of Rayonier, Inc., and Jay Grumbling was a Sanitary and Industrial Hygiene Engineering Officer, U. S. Air Force. Both engineers are alumnae of the M.I.T. Graduate School. Dr. James M. Symons of the M.I.T. Faculty has also joined the staff of Industrial Wastes as a Contributing Editor.

Dr. James C. Lamb, III, has been appointed Associate Professor of Sanitary Engineering in the Department of Sanitary Engineering of the School of Public Health, University of North Carolina. Since 1955, Dr. Lamb has been serving as a sanitary engineer with American Cyanamid Company, Bound Brook, New Jersey. He has been responsible for the technical aspects of the industrial waste program including the laboratory and pilot plant work which culminated in the complete process design, construction, and initiation of operation of a $4,500,000 waste treatment plant at Bound Brook. Since receiving his undergraduate education in civil engineering at Virginia Military Institute and his graduate education, leading to the Doctor of Science in Sanitary Engineering, at the Massachusetts Institute of Technology, Dr. Lamb has held teaching positions at V.M.I. and the Newark College of Engineering and has served as special lecturer and research associate in sanitary engineering at M.I.T.

The position of Director, Washington State Pollution Control Commission, vacated by Harold Miller's departure to direct the new metropolitan district of Seattle, has been filled by Mr. Art Garton. Mr. Garton is a former chairman of the Commission and director of the State Department of Conservation. He is not, however, an engineer as have been his two predecessors.

Leonard B. Dworsky has been designated Dept. of Health, Education, and Welfare representative on the Columbia Basin Inter-Agency Committee. Mr. Dworsky is in charge of water supply and water pollution control activities for the Public Health Service in the Pacific Northwest with headquarters in Portland.

Donald E. Gray, consulting engineer of Yakima and Seattle, has been named chairman of the Advisory Committee on Sanitary Engineering of the Institute of Technology, State College of Washington, succeeding R. Trumbull Smith of Seattle. The election took place at the close of the committee's annual meeting in Pullman, March 13-14. Other members present were E. J. Allen, Seattle; Emil C. Jensen, Seattle; and Vinton W. Bacon, Tacoma. The committee reviews the academic work in sanitary engineering offered by the Department of Civil Engineering, and research program of the Sanitary Engineering Section, Division of Industrial Research. G. H. Dunstan is head of the latter.

The State College of Washington will become Washington State University on September 1, 1959.

* * *

Sanitary Engineering Education

New Curriculum at Syracuse University

The Department of Civil Engineering of Syracuse University offers a new curriculum available to persons holding B.S. degrees in Engineering, Chemistry or Bacteriology leading to the degree of Master of Science in Sanitary Engineering.

Research Assistantships, available in this program commencing June 1, 1959, have a remuneration of $3,000 per year, plus remission of tuition and fees.

Address inquiries to Chairman, Civil Engineering Department, Syracuse University, Syracuse 10, New York.

College Recruiting for a State Health Department

Copies of a leaflet, "Your Opportunity for a Career in Sanitary Engineering with the Pennsylvania Department of Health" are being used in personal contact work with college engineering students by representatives of the Department's Sanitary Engineering Division. On-campus contacts are part of a planned recruitment program being conducted at numerous colleges and universities in the State. A major objective is to encourage applicants for career service with the Department's central and seven regional offices.

Taft Center Specialist Lectures on Industrial Wastes in Brazil

Hayse H. Black, Industrial Wastes Consultant, Robert A. Taft Sanitary Engineering Center, recently conducted a series of short courses in Brazil. This training program consisted of lectures on control and treatment of wastes for each of the major industries in Brazil, and on the application of stabilization ponds to waste treatment. These short courses were given in Rio de Janeiro and at the State Universities in Sao Paulo, Porto Alegre, Curitiba, and Belo Horizonte. Some 125 of the leading Sanitary Engineers and Sanitary Chemists in Brazil participated in this program.

Mr. Black spoke on design criteria for waste stabilization ponds at the Third Seminar of Professors of Sanitary Engineering in Brazil, which was held at Belo Horizonte, and gave an illustrated talk on the application of stabilization ponds to waste treatment before a Joint Meeting of the Interamerican Association of Sanitary Engineering (AIDIS) and the Technical Division of the Institute of Engineering in Sao Paulo. This project in Brazil was one phase of the public health and sanitary engineering program sponsored by the International Cooperation Administration.

Survey of Graduate Education in Sanitary Engineering

The Office of Engineering Resources, U. S. Public Health Service, is surveying a sample of the institutions active in graduate training for sanitary engineers to obtain the latest information on the future staffing and facility needs of sanitary engineering schools. By projecting this sample, Engineering Resources hopes to provide more adequate information to enable all sanitary engineering schools to obtain an equitable share in programs for support of such graduate education through the media of fellowships and research assistance.

The above survey is supplemental to (and endeavors to avoid duplication of) the information being gathered by the Subcommittee on Sanitary Engineering Education of the Joint Committee for the Advancement of Sanitary Engineering under the chairmanship of Professor Gilbert H. Dunstan. The Subcommittee, with the assistance of the Public Health Service, is preparing an inventory of admission requirements; requirements for master's intermediate, and doctoral degrees; and existing facilities and staff of all schools offering graduate degrees. They are also preparing a roster of sanitary engineering instructors. The inventory and the roster will be kept current by periodic revision. The list of schools will be made available in published form for use by faculty, college counsellors, and students. The roster will be used to supply useful information to the listed instructors.

Traineeships in Sanitary Engineering

In addition to the 116 environmental health traineeships awarded by the Public Health Service at the beginning of the 1958-59 academic year, 9 new traineeships (8 to engineers and 1 to a sanitarian) were recommended to the Surgeon General in January 1959. Of the nine, two were special recommendations for predoctoral candidates in sanitary engineering leading to teaching careers.

* * *

Sanitary Engineering Research

Grants for Building and Equipping Sanitary Engineering Research Facilities

During the first part of fiscal 1959, Public Health Service grants for building and equipping research facilities in the field of sanitary engineering were made to 10 institutions in the amount of $119,728.

University of Florida	Equipment	$ 3,262
Florida Engineering and Industrial Experiment Station	Air Pollution Laboratories	8,330
University of Kansas	Center for Environmental Health	52,875
University of Minnesota	Remodeling Laboratories	5,000
Rutgers University	Equipment	4,079
New Mexico College of Agriculture & Mechanic Arts	Laboratory	20,675
Cornell University	Facilities	10,685
Manhattan College	Facilities	10,822
University of Texas	Facilities	4,000

Sewage Stabilization Pond Studies in Oregon

The 1958 Annual Report of the Oregon State Sanitary Authority states that because of their economical construction and operation sewage stabilization ponds continue to receive much consideration as a possible method of sewage disposal for several communities throughout the State. Seven ponds have already been completed or are under construction and three more cities are planning to build facilities of this type in 1959 to replace existing overloaded conventional treatment plants.

In order to determine proper design criteria for sewage stabilization ponds to be used under climatic conditions prevailing in western Oregon, the State Sanitary Authority in sponsoring a research study by the Engineering Experiment Station of Oregon State College. An experimental stabilization pond has been constructed at the site of the Corvallis municipal sewage treatment works. The information obtained from this study will supplement the data obtained from the 1957-58 study conducted of the Long Beach, Wash., stabilization pond by the USPHS, Washington Pollution Control Commission, and the Oregon State Sanitary Authority.

New Equipment at Taft Sanitary Engineering Center

A large-scale, mobile, carbon filter sampler and extractor, built to SEC specifications to permit a 100-fold scale-up of operation, has been delivered to the Water Supply and Water Pollution Program. The ability to obtain larger samples in shorter time will permit extended analyses in both physiological and toxicological studies. Also, continuously recording D.O. analyzers built to SEC design are now in operation at the Center and at several field locations.

The National Water Quality Network staff has developed a sampling facility consisting of a jet pump and equipment for filtering and backwashing on alternate cycles of 55 and 5 minutes, respectively. The equipment is housed in a wooden structure which permits shipment with full assembly and requires only connections to a power source and an intake pipe. Two of the units built in the SEC Model Shop are now ready for field trials.

National Air Pollution Research Goals

The Ad Hoc Committee on Air Pollution Research Goals met on March 11 in the first of a number of meetings scheduled to outline a desirable total national research effort in air pollution over the next 10 years and to delineate the respective roles and responsibilities in this research effort of the Federal Government, State and local governments, industry, universities, and other organizations.

Public Health Service staffs presented, for the committee's consideration, background information on recommended research; an estimate of the current national effort on air pollution research; and United States trends in research expenditures, population growth, and increase in the gross national product. The presentation summarized the recommendations resulting from earlier meetings of other groups: WHO's Expert Committee on Environmental Sanitation, the Air Pollution Research Planning Seminars, the Conference on Man Versus Environment, and the National Conference on Air Pollution. After extended discussion, an "Outline of Committee Report" was agreed upon.

It is expected that two more meetings will be needed before the final report is ready. Committee members were asked, in the interim, to submit written comments on the recommendations; to make such additions, deletions, and revisions in this study as they see fit; to indicate the relative priorities of the research needs agreed upon; to estimate the approximate cost of each; and to define the primary responsibilities of each of the governmental and other groups concerned.

* * *

Water Supply and Water Pollution Control

Illinois State Chamber of Commerce Pioneers in Water Supply Planning

A new publication of the Illinois State Chamber of Commerce entitled "Will There Be Enough Water When You Need It" represents a pioneering effort by the State Chamber's Water Resources Committee designed to call water supply problems to the attention of its members and to provide them with a guide in working for their solution.

The report explains the essential parts of a water supply system, major water supply needs, obstacles to water works improvement, facts members should know about their water systems, sources of information about individual water works, the business man's responsibility, how the State Chamber can help its members in this regard, and what some State communities and areas have done towards meeting their water supply needs.

If the State Chambers of Commerce in the remaining 48 States would take similar action, our progress in this vital field would be hastened considerably. The address of the Illinois State Chamber of Commerce is 20 North Wacker Drive, Chicago 6, Illinois.

Waltons Urge "Responsible" Industry to Back Pollution Laws

Industries with good water pollution abatement records ought to stop "shielding industry elements shirking a fair share of the clean waters fight" and support strong Federal anti-pollution legislation, according to an analysis of industrial waste treatment problems in the March issue of Outdoor America, monthly magazine published by the Izaak Walton League of America.

In a lead article entitled "The Wrong Enemy," League Executive Director Frank Gregg asks why "responsible" industries heavily dependent on water supplies should not "dissociate themselves from the footdraggers among them and add support for strong legislation to their record of progress in waste treatment."

Acknowledging that industry reluctance to support strengthening of Federal powers is "pretty deeply ingrained," Gregg states that ". . . there is little in the record to indicate that either pollution control authorities or responsible conservation-minded citizens are eager to bite the industrial hand that feeds us all"; and defends Federal enforcement on interstate waters as "a legitimate, indeed a necessary, function of the Federal government."

The author urges industry support for continued appropriations for the program of Federal grants to communities for sewage plant construction and continuation of enforcement features of the present Federal law, Public Law 660, as a "proper means" of seeing "natural resources managed and used to serve the legitimate needs of as many people over as long a period of time as intelligence and foresight will permit."

Industry Cooperates with Municipalities in Waste Treatment

Teamwork on the Potomac—a recent publication of the Interstate Commission on the Potomac River Basin—cites an interesting example of cooperative effort by industry and municipalities towards pollution abatement. The serious pollution, of many years' standing, emanating from the West Virginia Pulp and Paper Company at Luke, Maryland, is undergoing a change. Under the terms of an agreement between the Company and the Maryland Water

Pollution Control Commission, the Luke plant is installing waste treatment facilities. Facilities to treat 6 million gallons per day of paper mill waste waters went into operation in January, 1958. An activated sludge plant of 20 million gallons capacity, which will treat the wastes from the pulp mill, is now under construction. The facilities of the activated sludge plant have been offered to the tri-towns of Luke, Md., Westernport, Md., and Piedmont, W. Va. for the treatment of their domestic sewage.

Water Pollution Control Advisory Board

The Presidentially-appointed Water Pollution Control Advisory Board, at its December 1958 meeting, adopted resolutions which: (1) Questioned the Joint Federal-State Action Committee's proposal to transfer the sewage treatment plant construction grants program to the States, and advised the Surgeon General that such a proposal, in the Board's opinion, is not feasible; that the present program is operating effectively and should be continued, possibly with increased appropriations for this purpose; (2) urged continuation of the construction grants program in the Public Health Service; (3) favored continuation of the State program grants provision of P. L. 660 for a minimum period of 10 years, in line with views of the majority of the administrators of State water pollution control programs; (4) expressed satisfaction with and support of the interstate enforcement activities and progress of the Public Health Service under the enforcement provisions of P. L. 660; (5) reiterated the Board's position favoring legislation to permit rapid tax amortization for construction of industrial waste treatment facilities; (6) confirmed the Board's position on the "minimum degree of treatment" standard, as defined in the PHS regulations, as a requisite for an applicant to become eligible for a Federal grant for sewage treatment plant construction; (7) urged development of an adequate educational program to make the public aware of the Nation's serious water pollution problem; and (8) urged that the Surgeon General and the Secretary of the DHEW request increased funds for administration of the Water Pollution Control Program, and particularly for development of an effective public awareness program.

New York Court of Appeals Upholds Stream Classification

In two 6-to-1 decisions, the New York Court of Appeals sustained the power of the State Water Pollution Control Board to classify waters according to the desired degree of cleanliness and to enforce these standards. The court ruled that the Board should base its decisions as to purity standards on the scientific facts of each case, rather than on how much pollution abatement might cost any given community.

State Legislation

North Carolina.—The creation of a new Department of Water Resources to handle functions now scattered among several State agencies will be proposed to the 1959 Legislature by the Commission on Reorganization of the State Government. The proposed new agency would eventually be responsible for the existing water programs of the State Board of Water Commissioners, the State Stream Sanitation Commission, and the State Department of Conservation and Development. To prevent disruption of the present pollution control

program, the State Stream Sanitation Commission would be an independent unit of the new department until 1965.

The North Carolina State Stream Sanitation Committee will recommend two important items of legislation to the 1959 Legislature. One would create a $2.5 million revolving fund for long-term loans to aid cities and towns in building sewage treatment plants. The second would put stream sanitation responsibilities for unincorporated towns in the hands of county Boards of Commissioners. No governmental unit is now charged with such responsibility.

Pennsylvania.—The Department of Health is proposing two bills, concerning the matter of State grants-in-aid. The first of these would provide for State grants toward construction of sewage treatment works, similar to the Federal grant program for the same purpose. The State grants would permit the extension of such aid further down the line of eligible communities. It would appropriate $2,000,000 annually for this purpose, and it would authorize State grants of up to $4,000,000 annually, the intent being that in the event that Federal grants for this purpose were terminated or curtailed, an equivalent additional amount could be appropriated by the State.

The second of these two bills provides that the amount of the grant made to any community under the provisions of the first bill would be deducted from any grants made to that community under P. L. 339 (the State program for annual payments of up to 2% for construction and operation of sewage treatment plants).

West Virginia.—A bill introduced in the State Legislature would amend present laws to make the State Water Commission into a State Water Resources Commission with much broader powers covering all phases of water resources.

Oregon.—The Oregon Legislature has before it a bill to combine the State Sanitary Authority and the State Air Pollution Authority. Another bill provides for creation of a Department of Natural Resources. The Governor has recommended that the now separate office of the State Water Engineer be included within the Oregon Water Resources Board.

Recommended Practices for Curbing Oil Pollution Adopted by Orsanco

Recommended practices for curbing water pollution from the use, transfer and storage of oil, with particular reference to the operation of tank vessels, terminal plants and marine service stations, were adopted by the Ohio River Valley Water Sanitation Commission on February 6. As outlined by Edward J. Cleary, Executive Director and Chief Engineer, the measure was developed by the eight states in the Ohio Valley to provide a practical guide for implementing the Commission's oil pollution control program.

Collaborating with the ORSANCO Engineering Committee and staff in compiling this draft were: The Oil Refining Industry Action Committee of the Commission, the American Waterways Operator's Association and the 2nd District Headquarters of the U. S. Coast Guard. As a result of this measure the Coast Guard now includes questions on the examination for tankerman certification relating to water pollution control responsibilities.

Pollution Control Progress Found Satisfactory in St. Louis Area

Satisfactory progress is being made in developing specific programs to eliminate pollution in the Mississippi River by adjacent Illinois communities and the Metropolitan St. Louis Sewer District, a spokesman for the U. S.

Public Health Service announced, following a progress report meeting late in January between officials of the local state and federal government agencies involved, at the Bi-State Development Agency's office in St. Louis.

This conference was the second in a series of regular report meetings agreed to on March 4, 1958, when a comprehensive program of sewage treatment and pollution abatement by MSD was announced after a conference with the U. S. Public Health Service.

Attending the conference were Murray Stein, chief of the enforcement division of the U. S. Public Health Service, Jack K. Smith, executive secretary of the Missouri Water Pollution Board, H. W. Poston and Herbert C. Clare of the Public Health Service's Chicago and Kansas City regional offices respectively, F. W. Kittrell of the Robert A. Taft Sanitary Engineering Center, Cincinnati, and C. W. Klassen, technical secretary of the Illinois Sanitary Water Board.

At the request of the conferees, William Q. Kehr, executive director of the Metropolitan St. Louis Sewer District, was also present to report on progress being made by MSD.

The federal government representatives and Smith expressed grave concern over the defeat of the Gravois Creek sanitary trunk sewer bond issue which they described as "an integral part" of the Sewer District's overall pollution abatement program, but expressed themselves as otherwise satisfied with the progress being made by the Sewer District and nearby Illinois communities.

The St. Louis Metropolitan Sewer District has signed a contract with Horner & Shifrin, St. Louis Consulting Engineers, for an anti-pollution study as a first step in a metropolitan-wide pollution abatement program. The $240,000 contract covers a 30-month study of the sources of pollution, number and types of treatment plants to be built, sludge disposal and recommendations for financing the project.

In addition to St. Louis, the following Illinois communities are affected in the bi-state pollution abatement program: East St. Louis, Alton, Wood River, Hartford, Granite City, Madison, Venice, the East Side Levee District, Brooklyn, Cahokia, Fairmount City, National City, Washington Park, and Monsanto.

Hearings on Amendments to Federal Water Pollution Control Act

Hearings by the House Public Works Committee on House Bill 3610 commenced on March 18 in Washington. This bill, introduced by Representative John A. Blatnik of Minnesota, would amend Section 6 of Public Law 660 (84th Congress) concerning Federal grants for the construction of municipal sewage treatment works, as follows:

1. Increase annual authorization for appropriations to $100 million and 10-year aggregate to $1 billion.
2. Increase maximum grant for a single project from $250,000 to $500,000.
3. Allow municipalities to band together for a single treatment works and be eligible for individual grants for the project.
4. Allow reallocation of unused state allotments to states where treatment works needs far exceed available funds.
5. Establish an Office of Water Pollution Control under the Secretary of Health, Education, and Welfare.

Proponents outnumbered opponents 13 to 1 during the first day of the hearings. The representative of the National Association of Manufacturers was the only dissenter in almost five hours of testimony. Hearings continued on March 19 and were then postponed until early in April.

* * *

Air Pollution

Third Edition of "Instruments for the Study of Atmospheric Pollution"Now Available

The third edition of Instruments for the Study of Atmospheric Pollution has just been published. This booklet lists hundreds of devices ranging from filter samplers to gas chromatography equipment as well as many others of corollary nature. Every aspect of the instrumental investigation of air pollution has been covered. The names and addresses of suppliers of this equipment are provided in an easily usable form. The publication has been completely revised with numerous additions. It is one of the continuing activities of Subcommittee No. 2 on Current Projects and Trends of the ASME Committee on Air Pollution Controls. Arthur C. Stern, Chief, Air Pollution Control Program, U. S. Public Health Service, Cincinnati, Ohio, is chairman of the subcommittee. G. V. Williamson, Vice President, Union Electric Company of Missouri is chairman of the main committee. The new booklet may be purchased for $2.00 from the Order Department, the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

Los Angeles Public Favors More Air Pollution Controls

According to a poll conducted recently by the Los Angeles Mirror, with some 4,000 replies, readers favored by huge majorities the imposition of strict controls over automobile exhaust gases, through both State and Federal legislation. The margins ranged from 6 to 1 for State inspection of motor vehicles to limit production of air pollutants—with motorists paying the inspection fee! up to 93 to 1 for establishment by the State of compulsory standards to limit the smog-producing content of various motor fuels.

On the question of forbidding the sale of new or used cars which emit more than a certain maximum of hydrocarbons, the voting was 16 to 1 for a State law to that effect and 25 to 1 for a Federal law. By a margin of 10 to 1, those replying voted "yes" to the suggestion that "Congress should authorize and finance a crash program of research into the medical aspects of smog, to be carried out by the U. S. Public Health Service.

Portable Air Pollution Laboratory

Satisfactory results are reported in field tests of the field analysis kit for air pollutants being developed by the Public Health Service under contract with Kem-Tech Laboratories at Baton Rouge. A highly portable laboratory for field use, this kit provides a means of delineating rapidly the nature of any air pollution problem. Delivery on the prototype is expected within two months.

Precipitation Chemistry Study

A precipitation chemistry study planned by the Air Pollution Engineering Research Program of the Public Health Service will collect precipitation samples monthly at some 30 stations. The Meteorology Section of the Program will arrange for the collection and the National Air Sampling Network Section will carry out the chemical analyses. This study is expected to shed light on the removal of air pollutants over urban areas by natural precipitation.

* * *

Nuclear Energy

Congressional Committee Told of Nuclear Wastes Problem

The Joint Senate-House Committee on Atomic Energy opened hearings late in January on atomic wastes with warnings that the development of the nuclear energy industry will be hindered unless more satisfactory methods are found for the disposal of radioactive wastes.

Dr. Abel Wolman, of Johns Hopkins University, was reported to have told Committee members that while there is no present hazard, the problem remains to be a great extent "unresolved." He stated that wastes are now controlled in two ways—those with a low level of radioactivity are dispersed in the air, water and soil, with more dangerous materials stored in underground steel and concrete tanks. Wolman advised the Committee that rapid development of the atomic energy industry will be "in no small measure contingent upon prompt and more complete answers."

Representative Chet Holifield of California, chairman of the Joint Committee's Radiation Subcommittee, said that the long life of some radioactive wastes makes it necessary under present methods of disposal to hold hundreds of gallons of highly dangerous material for 100 to 5,000 years. He described the disposal of radioactive wastes as an international problem and indicated that international standards and safeguards may be needed.

Decontamination of Radioactive Waters

The Report of the Joint Program of Studies on the Decontamination of Radioactive Waters is now available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., for $1.00.

For the most part, the information in this report on water decontamination and related problems is from the Joint program at the Oak Ridge National Laboratory. Experimental results indicate the extent to which natural agents may concentrate radioactive materials. Water decontamination findings are discussed in relation to the treatment process involved.

Model State Radiation Protection Acts

Model state radiation protection acts have been prepared by the Program Area Committee on Radiological Health of the American Public Health Association in cooperation with a special committee of the Conference of State Sanitary Engineers and the Special Health and Medical Services Committee of the Association of State and Territorial Health Officers.

The American Public Health Association in its explanatory comments on the model acts states that "The development of radiation controls throughout the country on the basis of uniform laws will permit exchange between States of facts and procedures established and applied thereunder, thereby enhancing the likelihood of increased uniformity of radiation controls in the Nation. Maximum uniformity is desirable to effect economy and efficiency for government and industry in the performance of their respective responsibilities. Enactment of the suggested Act would establish a common base for development of radiation protection regulations. Exchange of information between States enacting this Act including administrative as well as judicial decisions will enhance the likelihood of increased uniformity in regulations."

The address of the American Public Health Association is 1790 Broadway, New York 19, New York.

* * *

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